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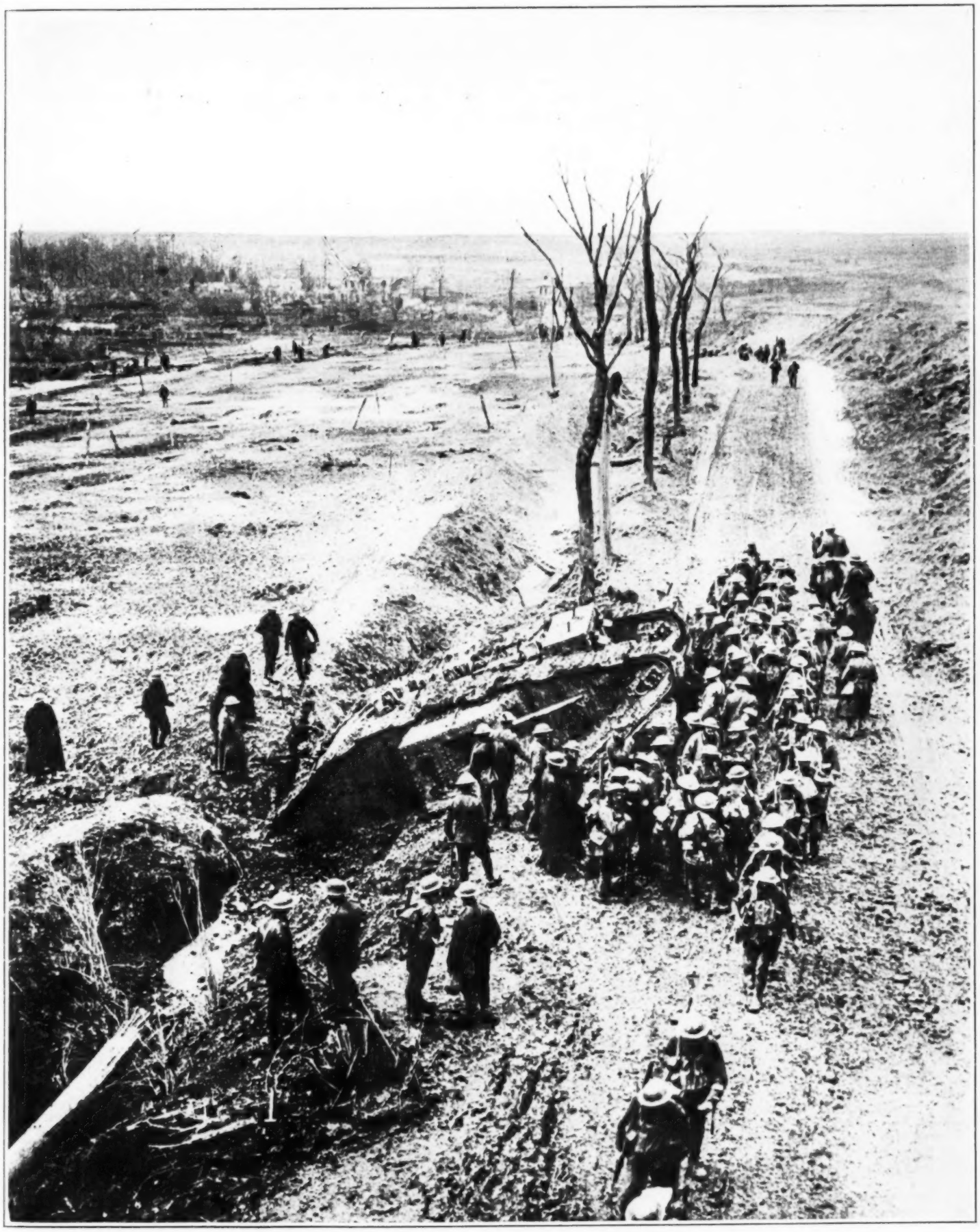


A British tank and troops on their way to take up positions for an advance

MECHANICAL CAVALRY [See page 312]

The Determination of Stellar Distances*

Ways in Which Our Knowledge Is Being Extended

By Sir F. W. Dyson, Astronomer Royal, Greenwich Royal Observatory

THE interests of astronomers are divided between the study of the solar system and the great universe of stars of which the solar system is a mere unit. There are numerous problems still unsolved connected with the sun and planets, which attract physicists and mathematicians as well as astronomers. In the main, however, the efforts of astronomers during the present century have been devoted to the extension of our knowledge of the stellar universe. Observations on a large scale have been made in many different directions. Measurements of parallax, spectroscopic classification, proper motions, velocities in the line of sight, photometry, color determinations, double stars and variable stars have been extensively investigated. These different researches have thrown light on one another, and have all contributed towards a true description of the present state of the stellar universe. In such a description the most important element is the distance of the stars from us. A knowledge of the distance is essential to a complete determination of the position, the velocity, the luminosity and the mass of the star. On the other hand our general knowledge of the velocities, luminosities and masses of stars can be used as guides to their distances.

From the time of Copernicus, astronomers have looked for an annual movement in the apparent positions of the stars due to the shifting positions of the earth as it travels round the sun. This causes a star which is comparatively near to us to appear to describe an ellipse in the sky with reference to the background of more distant stars which are in the same direction as seen by us. The changes we see are small angular changes and provide a measure of the parallax or small angle subtended by the radius of the earth's orbit at the distance of the star. The parallax of a star is thus the reciprocal of the distance,—a parallax of one second of arc (1″) implying a distance of 200,000 times the distance of the sun from the earth, 0″.5 double this distance and so on. With the progress of astronomy it has become possible to measure angles with continually increasing accuracy. The large photographic telescopes especially have contributed to this. It is possible now with a very few photographs to determine a parallax as small as 0″.05, or measure a distance of 4 million times as great as that of the sun. Naturally, great care and special precautions must be taken both in obtaining photographs and in their measurement. The accuracy with which these angles can be measured may be put down as ±0″.01, and considerable confidence can therefore be placed in measures of distance which are not more than 4 million times that of the sun, and even greater distances can be determined, though somewhat roughly.

Within a sphere of this radius, it should then be possible to locate all the stars which are sufficiently bright for observation. It is only necessary to know which to look for. For this the apparent movement of the star on the face of the sky forms a good guide. If stars of proper motion greater than 20″ a century be examined, about 1 in 5 are found to be within this limit of distance. Probably 800 stars may be ranged in this way, though up to the present the number known is under 100. It is important that the region of space around the sun should be thoroughly scrutinized. It provides us with information about all the individual stars and not merely the average results with which we have to be content in other cases.

Another method which has led to the determination of the distances of individual stars was published a few years ago by L. Boss. He found a loose collection of stars in the Hyades which were all apparently moving to one point in the sky. He interpreted this as meaning that these stars are actually moving in directions parallel to the line from the sun to this point of the sky. Further, the stars must all have the same velocity, or they would not remain in existence as a cluster. This velocity is determinable from spectroscopic observations of one of the stars, and when it is known, the angular motion of each star on the face of the sky can be used to find its distance. In this way the parallaxes of 40 stars ranging from 0″.021 to 0″.031 have been obtained. Other clusters of a similar character have been found. They give much food for thought, but are referred to here as contributing to the number of individual stars whose distances are known.

Let us next consider a method which gives the average distances of stars, although not the distances of individual stars. It was pointed out by Herschel that the community of direction of the proper motions of stars, i. e. of their angular motion on the face of the sky, might be explained by a movement of the solar system towards a point in the sky not far from the bright star Vega. A large number of subsequent researches have established this firmly. Further, spectroscopic observations of velocities in the line of sight, especially at the Lick Observatory, have determined the velocity of the solar system as 19.5 kilometres a second. This movement carries the solar system in one century 410 times the distance of the earth from the sun. The outlook from the solar system is thus perceptibly changed in a century. If the stars themselves were stationary, the distances of thousands of them could easily be determined from the extremities of such a long base-line, but as they are all moving, this cannot be done. We may, however, take a group of stars and, on the assumption that the peculiar motions of the stars themselves are haphazard, may attribute the general movement of the group to this motion of the solar system in the opposite direction. This method has been applied to find the mean distances of stars of different magnitudes. For example, those of magnitude 6, i. e. those just visible to the naked eye, are found to have a mean parallax of 0″.012, corresponding to an average distance of 18 million times the sun's distance. As we proceed to groups of fainter stars, the average distance increases, due to the inclusion of more distant stars, but in the group of fainter stars there are many which are no more distant than the brighter ones, these stars appearing fainter because they are intrinsically less luminous. It is found in this way that stars which are 100 times as faint as those just visible to us are not 10 times as far away, but only between 3 and 4 times the distance.

Instead of classifying the stars according to their magnitude or apparent brightness, the spectroscope enables them to be arranged according to their physical characteristics. If the spectra of different stars are compared, it is found, and it is an extremely remarkable fact, that they can be arranged in one continuous series. The lines in the various spectra may be due to helium or hydrogen, iron or titanium, but the chemical composition of the star is not the essential of the grouping; otherwise they would not fall, as they do, into one orderly sequence. Broadly speaking, the spectroscopic classification arranges the stars according to their temperature. It agrees with classification according to color, the blue stars being hotter than the sun, the yellow stars of nearly the same temperature, and the red stars cooler. When the proper motions of these different groups of stars are examined, those of solar type are found to be nearer to us than either the blue stars or the red stars of the same magnitude. In addition, spectroscopic measurements show that the peculiar motions are different for these different groups, particularly a group of stars at a very high temperature known in the Harvard classification as B stars and distinguished by the presence of lines due to helium in their spectra, have very small, peculiar velocities. Their proper motions are thus mainly due to the movement of the solar system. If then we assume that they are wholly due to this, their distances can be obtained. On this principle, or somewhat similar ones, the distances of these stars have been determined by Kapteyn, Plummer and Charlier.

So far we have utilized the apparent movements of the stars as the key to their distances. There are, however, two other methods which can be employed. The first is of somewhat limited application, and depends on the fact, brought out by Russell, Ludendorff and others, that there is no great range in the masses of stars. This is determined from double stars whose distances are known and from stars which spectroscopic observation shows to be double. The mass of a double star is measured by the pull between its components. This pull is by Kepler's third law determined by the distance apart of the two stars and the time they take to complete a revolution about one another. If there is a double star at an unknown distance, and we may assume that its mass is, let us say twice that of the sun, we may infer from the period of revolution what is the distance apart of the two components. Comparison with the angular distance apart, found by discussion of double star observations, gives the distance of the star from us. The distance of the stars from one another depends on the cube root of the mass, so that so great a change as an eight fold increase in the mass will only imply a two fold increase in the distance. This method is being developed in more detail as our knowledge of the actual masses of double stars of different types of spectra increases.

Methods of much wider application depend on our knowledge of the intrinsic luminosity of the stars. If we could say that a star would be equal in brightness to the sun when at the same distance from us we could infer at once its distance. This method was proposed by Huyghens and Lambert.[1] It cannot be applied in this crude manner because there are very great differences in luminosities among the stars: some, such as Canopus, give out more than a thousand times as much light as the sun, and a little star recently discovered by Barnard has only one three-thousandth part of the sun's luminosity. But there are types of stars in which there is not a great range of luminosity; for example, the B stars already referred to do not seem to have a great range. They are all very brilliant, say a hundred times as brilliant as the sun on the average, and they do not differ widely among themselves. Though some may be 3 times as bright as the mean and others only one-third as bright, half the stars will be found to be between these limits. In this manner Charlier has calculated the distances and positions of all the B stars. He finds that they form a spheroidal group with its short axis perpendicular to the plane of the milky way and one-third of the equatorial axis. The position of the centre of the group relative to the sun is also determined.

It is probable that this method may be extended to other groups of stars. The researches of Russell and Hertzprung have shown that the red stars may be divided into two groups, "giants" and "dwarfs," which are clearly separated. The "giant" red stars are of great luminosity, like the B stars, and there is not a very great range among them. The apparent magnitude should therefore be a very good measure of the distances of the class of stars and as they are many of them at such great distances that their movements, even in a century, are very small, will afford the most available and accurate means of finding their range.

A more suitable method of utilizing the light of the stars to determine their distances has recently been devised by Adams. Although the spectra of the stars do fall into one unbroken line dependent on their temperature, there are small differences with respect to particular lines which he has discovered and examined. We know that changes in spectra are produced by differences of pressure. It is therefore not surprising that differences may be detected between the spectra of a large and a small star which are at the same temperature. Differences in the force of gravity and the density of the part of a star near its surface, from which light reaches us, and which we analyze in the spectroscope, are to be anticipated. Adams has found marked differences between the relative intensities of certain lines in stars which are similar in spectral type and apparent magnitude, but which are known to be at widely different distances from us. He has taken the stars which are known to have parallaxes greater than 0″.05 and compared their spectra with those of stars known to be at very much greater distances, but which appear to us to be equally bright. The latter stars are much more luminous than the former. His measurements of relative intensity are found to give a reliable estimate of the luminosity, and from the luminosities the distances are readily inferred. For example, if there are two stars of equal apparent magnitude, and the first is known to be nine times as luminous as the second, then its distance must be three times as great as that of the second. It seems likely that this method will be extensively developed and will add very materially to our knowledge of the distances of stars.

A very striking application of the peculiarities of the light from certain stars has been made by Hertzprung to determine the distance of the smaller Magellanic cloud. Miss Leavitt, of Harvard College Observatory, had shown from the study of variable stars in clusters that for a certain peculiar class of variables known as Cepheids there existed a relationship between the period of variability and the apparent magnitude of the star. As the stars in the same cluster may all be regarded as at the same distance from us, it fol-

*From *Scientia*.

[1] Plummer, "The Observatory," 1916, p. 16.

lows that there is a relationship between the period of variability and the luminosity of a Cepheid variable. The necessary constant of the formula was inferred from a consideration of a number of the nearer Cepheid stars, whose mean distance could be derived from the solar motion. From this mean distance, combined with the observed magnitudes, the absolute brightness of Cepheids of different periods was derived. Now the smaller Magellanic cloud contains a number of Cepheid variables which are very faint on account of their great distance. From the period of their variability, combined with their apparent magnitude, the smaller Magellanic cloud was found to have a parallax of 0".0003.

I have attempted to show in what unexpected ways our knowledge of the distances of the stars is being extended. We rely on accurate determinations of parallax to furnish distances, which are wholly independent of the luminosity and physical characteristics of the stars. These are extended statistically by the combination of the study of proper motions and of the velocities of stars to or from us determined by the spectroscope. We are thus enabled to discover the relation between the luminosities of stars and their physical characteristics indicated by their light and its analysis. These characteristics are then applied to determine the distances of stars which are too far away for their movements to be appreciable. It is to the correlation of widely different researches that recent progress is due.

Four-Cycle Versus Two-Cycle Diesel Engines

THERE is no problem connected with internal-combustion engines that has absorbed so much attention, and to which such a large amount of discussion has been given, as that of the relative merits of the four-cycle and the two-cycle principles. This is true in general for all types of internal-combustion engines, but where the Diesel engine is concerned the question is still more potent in that the Diesel principle lends itself well to units of comparatively large power on account of the fact that the fuel is only introduced into the cylinder at the moment of ignition. Thus for a given size of cylinder the heat stresses are, if anything, less with a Diesel engine than with a gas engine.

The larger the power, it is generally admitted, the better the case for the two-cycle principle, because of: 1. The limiting size of the exhaust valve of four-cycle engines for satisfactory working: 2. The better turning moment with two-cycle engines; 3. The smaller cylinder required with two-cycle engines to develop equal power in the same number of cylinders, although at a higher consumption of fuel per unit power developed.

Furthermore, the Diesel principle removes some of the most severe objections to the two-cycle principle. The scavenging with Diesel engines is carried out by air and air alone, instead of a mixture of air and gas, so that the danger of ignition of the incoming gas, or of the loss through the exhaust ports of part of the charge does not arise with the Diesel engine. The foregoing are the points around which general discussion has centered. In the following attention is confined solely to the Diesel engine.

The practice hitherto of makers of Diesel engines is varied. Some few have stuck firmly to the two-cycle throughout a large range of power, others have confined themselves exclusively to the four-cycle, whereas a few of the largest manufacturers build four-cycle engines up to a maximum of some 200 to 250 b.h.p. per cylinder, and construct only two-cycle engines above that power per unit, on the assumption that the higher the cylinder power the greater the attractiveness of the two-cycle engine. Moreover, for special work, where lightness and compactness are of the highest importance, such as for submarine work, the two-cycle engine has been credited with a greater capacity for fulfilling these requirements than the four-cycle engine, and theoretically, looking superficially at the subject, double the number of impulses achieved by the two-cycle principle should have justified this choice.

To attempt to conclude from the results of two-and four-cycle practice up to the present time without having reliable knowledge of all the facts, would simply open the way to a lenghty and probably useless controversy. It may be stated, however, that the two-cycle engine has not gained ground, in fact, the four-cycle if anything, even for higher and higher powers, is increasing in application and the claims to compactness and lightness of the two-cycle engine have not fully been substantiated by the results of actual practice.

It is not desired to forecast the distant future. It is sufficient to move in small steps, especially in internal combustion-work, and as throwing a certain light on the subject outlined herein. Messrs. Franco Tosi, of Milan, Italy, with commendable enterprise, have recently built two similar engines, one a two-cycle and one a four-cycle, which they have tested one against the other with a view to comprehensive comparison, and the results of these experiments deserve special attention.

In order that those tests may be regarded as comparative, the underlying principles of the two designs must be examined for sufficient similarity as a basis. From the drawings, which we hope to publish later, both show the same trend in design. Both are of the totally-enclosed, high-speed, forced-lubricated, trunk-position type of engine. The designed speed of revolution, and the method of carrying the main tension stresses are exactly the same in both cases, and the cylinder dimensions only vary slightly. The two-cycle engine has the six working cylinders in the center with a scavenging pump and a compressor at each end. The four-cycle engine has eight working cylinders with two compressors at the forward end as against the six working cylinders of the two-cycle engine. There are, naturally, a number of differences, apart from the main arrangement, required by the cycle of operation adopted, such as the cooling system of the two-cycle pistons and the scavenging valve gear, and with the four-cycle the valve gear and cylinder head for accommodating the various valves.

The next important point to which attention must be directed is the designed power of these engines, which is the same for both *i. e.*, 1,300 b.h.p., and which equals about 215 b.h.p. per cylinder, with the two-cycle and 160 b.h.p. per cylinder with the four-cycle engine. This size was chosen because the two-cycle engine is a standard submarine engine of the makers, and it is is to be noted in this connection that Messrs. Tosi are experienced designers of both two- and four-cycle Diesel engines. It might be urged that this size is not the best for a suitable comparison. If a lower power had been chosen then a great advantage might have lain with the four-cycle, certainly not conversely; but, on the other hand, if a larger size had been the subject of experiment it might be contended that the position—later to be exactly given—might have been reversed in favour of the two-cycle. There is the fact that with the four-cycle engine, two exhaust valves were accommodated in each cylinder head, and as has already been stated, it has been found in practice that under certain conditions the question of the exhaust valve has been a limiting factor in respect of the probable power output from a given cylinder and for a desirable reliability of continuous operation in practice. With this four-cycle engine, each cylinder has two inlet and two exhaust valves, and the exhaust valves are water cooled, not only in the cages, but also the valves themselves. This remains an outstanding point, although it must be conceded that 210 b.h.p. per cylinder for a two-cycle and 180 b.h.p. per cylinder for a four-cycle engine are no mean outputs, especially for the high-speed type of engine.

It remains to discuss the actual results, and to draw deductions therefrom. Lengthy tests were carried out, 145 hours continuous non-stop runs being made, and both engines developed their designed power of 1,300 b.h.p. at 300 r.p.m. It was found, however, that the two-cycle engine was not capable of developing higher than this figure, whereas the four-cycle engine at the same speed of revolution, 300 r.p.m., gave 1,450 b.h.p., and as a maximum power at higher revolutions developed 1,585 b.h.p. for a short period. As regards fuel and lubricating oil consumptions the advantage lies greatly in favour of the four-cycle engine. At full load, the four-cycle figure was 0.41 lb. of fuel, and lubricating oil per b.h.p. hour, whereas the two-cycle consumption was 0.573 lb. per b.h.p. hour. Fuel consumption tests were carried out at various powers and the advantage in this respect of the four-cycle at full power was well maintained at lesser powers.

In regard to flexibility, the four-cycle showed marked superiority. With the two-cycle engine at 300 r.p.m., the compression was 460 lbs. per sq. inch, whereas at 120 r.p.m., the compression fell to 315 lbs. per sq. inch, at which pressure the temperature generated would be insufficient to support combustion of heavy fuel oil, and so the engine would stop. With the four-cycle engine at 300 r.p.m., the compression pressure was 490 lbs. per sq. inch, and at 100 r.p.m., had only fallen to 445 lbs. per sq. inch.

The reasons for a fall in compression with a decrease in the speed of revolution are as follows:—1. Decreased revolutions are almost always accompanied by a diminution of power output, which means less fuel consumed, making for a cooler cylinder, and so less heat to be taken up by the induction air, and so a lower final compression pressure. 2. The compression leakage per cent. past the main tube rings is a function of the size of cylinder and of time. The smaller the time of compression, the less the leakage, so that when running at slow speeds the compression is lowered due to this cause. 3. Again, with slow running, the time element allows more heat to pass to the cylinder jacket, further reducing the pressure and temperature of final compression. These three causes are common to both two- and four-cycle engines. With two-cycle engines, the reason for the compression pressure dropping much more rapidly with reduced revolutions than with the four-cycle engine is on account of the scavenging air pressure.

The slower the speed of running the lower the pressure of the scavenging air, because of the lesser resistance against which the scavenging pump is required to deliver. In the working cylinder, where less fuel is being burnt, there are less gases to be expelled. Further, the time element enters into the question of leakage of scavenging air through the exhaust ports, so that, whereas at 300 r.p.m., the scavenging air pressure may be as high as from 5 to 6 lbs. per sq. inch at 120 r.p.m., it would be as low as 1.5 to 2.5 lbs. per sq. inch and the scavenging air pressure is that at which compression begins, and the final compression pressure falls in direct proportion on this account alone. On the other hand, with four-cycle engines, the pressure at which compression begins is substantially the same, irrespective of the speed of revolutions. This experiment further showed that the noise of running of the two-cycle engine was very much more than with the four-cycle, due to the suction of the scavenging pumps and the high speed of the valve gear. With two-cycle engines, the valve gear operates at engine speed, and with four-cycle engines at half-engine speed.

Messrs. Franco Tosi have decided, in future, to abandon the two-cycle principle, and to confine themselves to the four-cycle for reasons substantially as stated, which may finally be recapitulated:—1. Elimination of the scavenging air pumps with their receivers, diminishing thus the size of the engine and decreasing the noise. The four-cycle engine of equal power is, approximately, the same size and of the same weight as the two-cycle. 2. Lesser amount of heat units abstracted by the cooling water and the four-cycle engine contributing to the lower-fuel consumption with the four-cycle engine. 3. The inefficiency of scavenging with two-cycle engines, as compared with the four-cycle. 4. The possibility of using higher piston speeds with the four-cycle engine. 5. Greater flexibility of the four-cycle engine. 6. Simpler mechanical parts of the four-cycle engine. 7. The fuel pumps and valve gear of the four-cycle engine only ran at half-engine speed, making thus for easy running conditions.—*Engineering.*

Backing Photographic Plates

As soon as the photographic public realized the advantages to be obtained by backing gelatine plates, the plate-makers were not slow in supplying very efficiently backed plates as a regular line. Of course, they charged for the extra work, but the charge was trifling and the plates were cheap, so that we were very willing to avail ourselves of the convenience and to use backed plates whether the subject necessitated it or not. Now that plates have touched what, we hope, will be the high-water mark in price, the cost of backing has also increased, and we may well consider whether it is not worth while to revert to the old method of backing such plates as are actually required just before use. This used to be a simple matter in the old days, for few, if any, color sensitive plates were used, and a red or orange pigment sufficed for backing. This is hardly sufficient for orthochromatic plates, especially when a screen is used and the light transmitted is very similar to that reflected from the backing. Hence there has been a tendency to use a black pigment, such as lamp-black, instead of burnt sienna or umber, the black being quite efficent even with panchromatic plates. All that is needed is a little lamp-black, ground in water or beer, from the oilshop, some caramel, and a few drops of glycerine (if obtainable). The color is mixed with the caramel and as much water as may be necessary, and smeared thinly over the glass side of the plate. If the plate is to be used at once, there is no need to allow the backing to dry; but if a number of plates have to be prepared in advance, they must be placed in a rack and covered up until the color has dried on. It will be found, if methylated spirit is used instead of water in thinning the color, that the drying will be effected much more quickly. If a calcium box be handy, the plate rack may be placed therein, and there will then be no danger of the film becoming damp through the proximity of the backing.—*Brit. Journ. of Photography.*

Are You Collecting Sphagnum?*

A Sort of Moss of Great Value for Surgical Dressings

By Prof. George E. Nichols, Sheffield Scientific School

"Are you collecting Sphagnum Moss?" Such was the question that appeared in bold type on the front cover of the London Graphic for September 2, 1916. From this journal we learn that the collecting and drying of sphagnum moss and making it up into surgical dressings "has become a national industry" in Scotland, and that "the work is being extended all over England, Ireland and Wales." Within the past two years the sphagnum industry has assumed large proportions in Canada, and in our own country it is rapidly coming to the front as an important phase of Red Cross work.

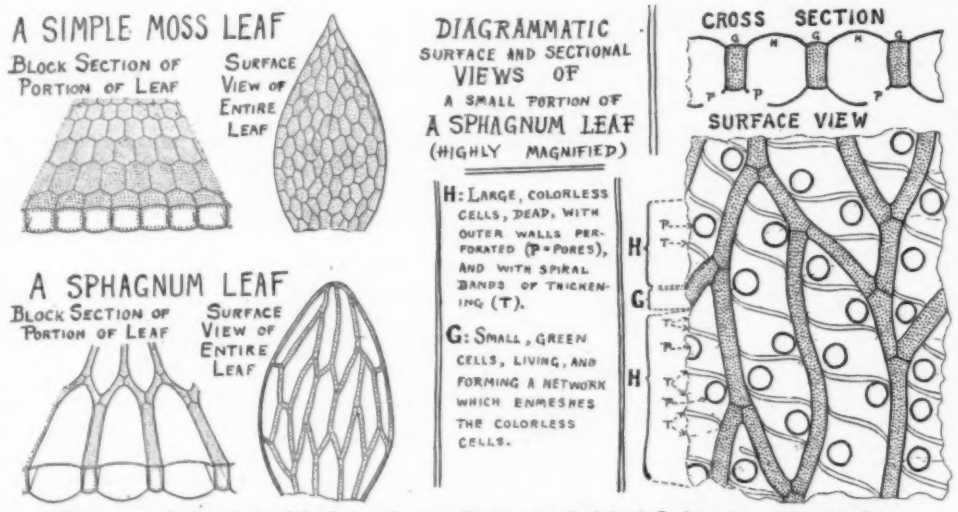
One very serious handicap to the sphagnum enterprise in this country is a lack of information regarding where to get material. Abundant supplies of good surgical moss have been located in the Pacific Northwest, but the transportation of material from this region to the East presents an obvious problem. At the present time, therefore, we are scouring the East for sources of supply which can be drawn upon in case of need. What can you tell us regarding the sphagnum situation in your locality? Are there any good supplies of surgical sphagnum?

Now of course very few people are in a position to furnish offhand the sort of information that we require. To perhaps most people the very identity of the sphagnum is veiled with mystery, and of those who may know it as a kind of "bog moss" few realize that there are a large number of different kinds. Even among botanists, who of all people should know it best, there are comparatively few who can distinguish between one kind of sphagnum and another, or, what is more to the point in the present connection, who can discriminate intelligently between surgical and non-surgical material. In the account which follows, I shall discuss some of the more important facts regarding the sphagnum moss as related to surgical dressings. I shall try particularly to answer some of the many queries which are constantly being made by people who are eager to help in securing information regarding our resources of surgical sphagnum.

First of all, how did sphagnum come to be introduced into surgical practice? Who discovered its adaptability in this connection?

Along in the late seventies of the last century a workman at one of the great peat moors in Northern Germany accidentally sustained a severe wound of the forearm. In the absence of anything better to use, his fellow workmen wrapped up the wound with fragments of the peat which happened to be lying near, and it was not until ten days later that the man was able to secure surgical attention. Imagine the surprise of the surgeon when, on removing the improvised dressing it was found that the wound had almost completely healed.[1]

With this incident the use of sphagnum in present-day surgery may be said to have originated. As a matter of fact, however, its use in this connection is not a new thing at all: it is merely a modern and scientific revival of a very ancient practice. In parts of Great Britain, according to Professor Porter,[2] from time immemorial bog moss has been used by country people in the treatment of boils and discharging wounds. In Scotland and Ireland it was employed many centuries ago for exactly the same purpose that it is being used today; and moss was "at least recommended for use by army surgeons, both in the Napoleonic and the Franco-Prussian wars."


A SIMPLE MOSS LEAF
BLOCK SECTION OF PORTION OF LEAF
SURFACE VIEW OF ENTIRE LEAF
A SPHAGNUM LEAF
BLOCK SECTION OF PORTION OF LEAF
SURFACE VIEW OF ENTIRE LEAF
DIAGRAMMATIC SURFACE AND SECTIONAL VIEWS OF A SMALL PORTION OF A SPHAGNUM LEAF (HIGHLY MAGNIFIED)
H: LARGE, COLORLESS CELLS, DEAD, WITH OUTER WALLS PERFORATED (P=PORES), AND WITH SPIRAL BANDS OF THICKENING (T).
G: SMALL, GREEN CELLS, LIVING, AND FORMING A NETWORK WHICH ENMESHES THE COLORLESS CELLS.
CROSS SECTION
SURFACE VIEW

Diagrammatic drawings of the leaves in an ordinary moss and in the sphagnum, as seen under a microscope, to show structural peculiarities

We must acknowledge our indebtedness to the Germans, however, for demonstrating the value of the sphagnum in the modern, anitseptic methods of surgery. Following the incident which I have related above, investigations were set on foot as to the nature and the properties both of the sphagnum and of the peat to which it gives rise, and a number of papers were published in German medical journals, in which the sphagnum, as related to surgical practice, was discussed from various points of view. And within a very few years this moss came to be accepted in Germany as a standard material for surgical dressings, being widely used not only in private practice but in some of the largest hospitals.

During the Russian-Japanese war, the Japanese used sphagnum quite extensively as a first-aid dressing. "Many of the wounds thus dressed with sphagnum were not inspected again until the patient reached Japan, which often took ten days, but almost invariably the wound was in good condition; much better it is said than when cotton was used."[3] In general, however, the value of sphagnum for use in surgical dressings has not been appreciated until quite recently.

To what extent is sphagnum being utilized in war hospital practice at the present time?

Shortly after the beginning of the war it began to be feared in England that there might be a shortage of cotton, and experiments were made with various materials—oakum, wood-pulp, and even sawdust—in the hope of finding some satisfactory substitute. It was at this time that attention was directed to the neglected possibilities of the sphagnum.[4] In 1914, sphagnum dressings were given a thorough try-out at one of the large war hospitals in Scotland, and the results proved so satisfactory that sphagnum was at once recommended for general use. In September, 1915, sphagnum dressings were formally accepted by the British War Office. At that time the total British output of sphagnum surgical dressings was barely 250 a month. A year later it had reached 150,000, and at the present time it is nearly a million. The Canadian Red Cross alone is now putting out between two and three hundred thousand sphagnum dressings each month.

In our own country the sphagnum enterprise, so far as the National Red Cross is concerned, is still in its infancy. But we have long since passed the stage of experimentation and have reached the stage where sphagnum dressings are being produced in considerable quantities. The American Red Cross has recently turned out half a million sphagnum dressings for the Italian army, and something over twenty thousand a month are now being made for American war hospitals. But the sphagnum work of the American Red Cross is not yet being conducted on the large scale which it is anticipated that it will be in the near future. For one thing, our American army surgeons, accustomed to the use of absorbent cotton and still having plenty of this on hand, hesitate about adopting a substitute. It is inevitable, however, that sooner or later the value of sphagnum in war hospital work will be more fully appreciated in this country: for the quality of the cotton is constantly becoming poorer, while the price is soaring higher. Moreover, wherever the sphagnum dressings have been tried out in our hospitals, they have given complete satisfaction.

For just what purpose is the sphagnum used in surgical work?

Sphagnum is used to replace cotton in absorbent surgical dressings—in what are known technically as absorbent pads, or compresses.

But, so long as there is plenty of cotton, why trouble with a substitute? And, if it is desirable to use a substitute, why select sphagnum rather than something else?

For use in absorbent surgical dressings sphagnum moss is not merely a satisfactory substitute. In many respects, without question, it is superior to absorbent cotton.[5]

First of all, sphagnum will absorb liquids much more rapidly than absorbent cotton—about three times as fast.

In the second place, the sphagnum will take up liquids in much greater amount than absorbent cotton. A pad made of absorbent cotton will absorb only five or six times its weight of water. An average pad made of sphagnum will take up sixteen to eighteen times its weight of water, more than three times as much as cotton, and exceptionally good moss will absorb as much as twenty-two times its weight of water.

In the third place, the sphagnum will retain liquids much better than cotton. This means, of course, that a sphagnum dressing need not be changed as often as a cotton dressing.

In the fourth place, "the better qualities of sphagnum have the valuable property of distributing whatever liquid they absorb throughout their whole mass." An absorbent pad of sphagnum will continue to suck up fluid discharges until it is pretty uniformly saturated throughout. This is a very important feature. A cotton pad ordinarily ceases to function long before its theoretical capacity has been reached.

Now in ordinary hospital work, as Professor Porter points out, the comparative inferiority of cotton as an absorbent is not of any great consequence. Here, for the most part, the wounds are the result of operations and they are made by the surgeon himself. They are comparatively slight, and, what is particularly important, they are perfectly sterile. Discharging wounds are exceptional. But in war hospital practice every wound may be taken as infected. Discharging wounds are the rule, not the exception. Furthermore, "the methods of treatment recently so successfully developed by Carrel, Dakin, and others deliberately increase these discharges to a very great extent. For such cases . . . sphagnum is greatly preferable to any other available material."

In this connection it might be mentioned that when it is dry, the sphagnum is very light, and many varieties are very fluffy. Sphagnum of the quality insisted on for surgical dressings is quite as soft as cotton.

Finally, there is one other point in which the sphagnum is distinctly superior to cotton; and this is a matter of great practical importance. Sphagnum is cheaper than cotton. Being a product of nature, pure and simple, all that you have to do is to go and get it, and practically the only expense involved is the cost

*From the *Journal* of the New York Botanical Garden. A Contribution from the Osborn Botanical Laboratory.

[1] This incident is related by Neuber (Arch. f. klin. Chir. 27:757-788. 1882), a German surgeon who at that time was connected with the surgical clinic at Kiel.

[2] Porter, J. R. Sphagnum surgical dressings. Internat. Journ. Surgery 30: 129-135. 8 *f. in text.* 1917. This comprehensive paper has been reprinted as a separate by the Canadian Red Cross.

[3] Hotson, J. W. Sphagnum as a surgical dressing. pp. 1-31. f. 1-18. Separate issued by the Northwest Division of the American Red Cross. Seattle. 1918.

[4] See especially a paper by Cathcart, C. W., and Balfour, I. B. in the Scotsman for November 17, 1914, and one by Cathcart in Brit. Med. Journ. 38: 137-139. 1915.

[5] The following observations are taken mainly from Porter, *op. cit.*

of collecting and transporting the material. As will be seen later, the process of preparing the sphagnum for use is very simple, and most of the work can be done by volunteer workers.

What does the sphagnum look like? How can you recognize it when you see it?

To begin with, the sphagnum is a sort of moss. But do not confuse the true mosses with the so-called "sea mosses." These are more correctly called sea-weeds: they are not the mosses at all. The true mosses are comparatively small, leafy plants, seldom more than a few inches in height. They grow in all sorts of places: in dry, exposed crevices of rocks, on the bark of trees, on the ground in swamps and moist woods, and even in the water. But they never grow in salt water. To an ordinary observer, perhaps, the mosses are conspicuous chiefly on account of the great masses of vegetation which they commonly form. The sphagnums include some of our largest and most conspicuous mosses.

The sphagnum differs from other kinds of moss in a number of important respects.

First of all, a sphagnum plant seldom exhibits the deep leaf-green color of an ordinary moss. When wet, it commonly is a pale green; when dry, it may be almost white. Very frequently the green is hidden almost completely by pigments of various colors, so that the plants may be almost any shade from bright red and pink to russet green and dark brown or almost black. These colors form a very distinctive feature of many sphagnums when they are fresh. In nature, their mass effect is very striking, and they are of great help when it comes to recognizing material in the field.

But color alone is hardly a sufficient test. Other distinguishing marks are afforded by the peculiarities of the branches and of the leaves. If you examine a single sphagnum plant, you will see, first of all, that it consists of a main axis, on which are borne numerous short branches. Further, you will note that these branches are not borne singly, but in clusters of from three to six. No other moss produces its branches in clusters, after the manner of the sphagnum. Along most of the stem these branch clusters are scattered, but toward the tip they usually grow so close together as to form a rather compact rosette which sometimes is mistaken for a flower. It might be added that the branches in each cluster are of two sorts: one kind stands out at right angles to the main axis; the other kind droops down alongside the stem and forms a sort of loose, spongy matting around it.

And not only is the arrangement of the branches on the stem distinctive. Quite as striking is the arrangement of the leaves on the branches. Every branch is completely covered over by a series of tiny, more or less spoon-shaped leaves, which closely overlap one another, somewhat after the manner of shingles on the roof of a house.

To what structural peculiarities does the sphagnum owe its efficiency as an absorbent?

To a limited degree certain of the features already described adapt the sphagnum to absorb liquids: the close overlapping of the leaves around the branches, and the sponge-like matting of the pendent branches around the stem. But the real secret of the sphagnum's efficiency as an absorbent lies in the remarkable microscopic structure of its leaves.

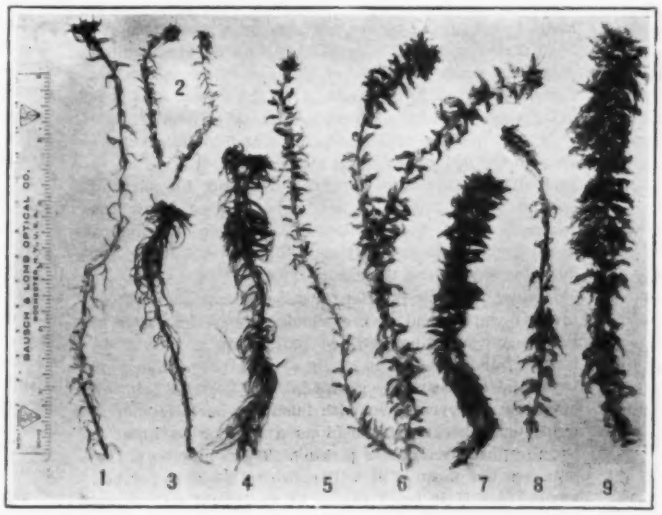
Before discussing the somewhat complicated sphagnum leaf, I will describe briefly the much simpler structure of an ordinary moss leaf, as it looks under the microscope. Such a leaf consists of a single layer of tiny microscopic cells. Seen in surface view the individual cells are polygonal in outline, but in reality, considered as solids, they are prismatic in shape. All of the cells in the leaf are essentially similar to one another: without exception they are green and living and they are all of approximately the same size and shape.

But in a sphagnum leaf the structure is much more complex. Here also there is just a single layer of cells, but these cells are of two totally different kinds. First, as in the ordinary moss leaf, there are the green, living cells. But these green cells, in the sphagnum leaf, are very small and very much elongated, and they are arranged to form a sort of open network which runs all through the leaf. In the meshes of this network occurs the second kind of cell. These cells are large, without color, dead, and perfectly empty. It is to the presence of these large, colorless cells and to their remarkable structure, which I shall describe next, that the sphagnum owes its wonderful power to take up liquids.

Now, to a certain extent, the cells of any moss leaf are able to absorb liquids. But the ability of the ordinary green cells in this respect is insignificant when compared with that of the large, colorless cells of the sphagnum leaf. These, because of their capacity for absorption, may well be referred to as the *absorbing cells*. There are two features in these cells which especially adapt them to the function of absorption. First, the wall of each and every one of the absorbing cells is punctured toward the outside by several minute holes or pores. It is through these pores that liquids are sucked into the cells. Each cell, acting independently, sucks in whatever liquid it comes in contact with until it is full. A sphagnum plant with its hundreds of leaves, each leaf containing hundreds of these tiny absorbing cells, represents a highly efficient absorbing system. And this absorptive ability is not confined to plants that are fresh. A dry, dead leaf is just as efficient, when it comes to taking up liquids, as a fresh one. This is due to the second structural peculiarity of the absorbing cells. For inside of each one of these cells there is a spiral, spring-like coil of thickening (or commonly a series of hoop-like ribs of thickening) which presses outward, as it were against the walls of the cell and serves to keep it from collapsing. Even after a leaf has become completely dried out, this "framework" serves to keep the cell cavity open.

Incidentally, while it is the leaves which are most efficient in the absorption of liquids, in some varieties of sphagnum both the stem and branches are enveloped by one or more layers of absorbing cells, essentially similar to those found in the leaves.

It now becomes perfectly clear why it is that sphagnum is so much superior to cotton as an absorbent. In cotton liquids, for the most part, are merely held within a tangle of threads. In the sphagnum we find a highly specialized absorbing system, made up primarily of a vast series of absorbing cells, but supplemented to a high degree by various other structural peculiarities of the sphagnum plant.



Forms of sphagnum suitable and otherwise for surgical dressings
For explanation see text

How can surgical and non-surgical varieties of sphagnum be distinguished from one another?

Just as there are a great many different varieties of roses and chrysanthemums and dahlias, so there are a great many different kinds of sphagnum; and these different kinds are by no means of equal value for surgical purposes. Some of them, indeed, are worse than useless. A great deal of the dissatisfaction with sphagnum dressings which was expressed by army surgeons in the early days of the sphagnum enterprise can be attributed to the failure to appreciate this difference, and to the indiscriminate use of any and all species of sphagnum in making up the dressings.

In the little State of Connecticut alone there are no less than twenty-five different kinds of sphagnum; on the continent of North America there are at least forty. Of these forty species only two or three are actually used to any extent for surgical purposes. It is not enough, then, to know that a sphagnum is a sphagnum. One must be able to differentiate between suitable and unsuitable varieties.

Now, from a botanical point of view, the sphagnums are an exceedingly difficult group of plants to work with. It is a job for an expert to properly identify specimens: in fact, it is a job which very few botanists feel qualified to undertake. Fortunately, however, the recognition of material suitable or otherwise for surgical purposes is much less difficult. With a little training and experience it is well within the ability of almost anyone to at least distinguish with some degree of certainty between sphagnum which very likely will prove of surgical value and sphagnum which quite certainly will not.

Without going too much into detail, then, we will consider next just what qualities are desirable in sphagnum material which is to be used in surgical dressings.

First of all, the highest possible capacity for absorbing liquids is essential; and with reference to this qualification there is a wide range of variation between different species. In general, the more robust varieties of sphagnum are better than the more delicate; forms with large leaves, dense foliage, and close-set branches are much better than varieties with small leaves, skimpy foliage, and scattered branches. In the second place, it is essential that the material should be soft and flexible, and at the same time that it should possess a considerable degree of strength. Here again there is great variation between different species. In general, coarse or stringy forms, or forms with stiff or brittle stems or harsh texture, must be avoided.

Of all the sphagnums, there is one species which combines, to a greater degree than any other, absorbency, softness, and strength. This is *Sphagnum papillosum*. This species, at least here in the East, has been found to be much more satisfactory for use in surgical dressings than any other variety. Three other species of sphagnum have been used to a considerable extent in surgical work, namely *S. palustre*, *S. magellanicum*, and *S. imbricatum;* but while in the humid climate of western Washington and British Columbia these develop quite as luxuriantly as *S. papillosum*, and while locally, here in the East, they may compare very favorably, on the whole they tend to have too much stem in proportion to foliage or too harsh a texture to make ideal surgical material. In the field *S. papillosum* can usually be recognized by its very robust habit and brownish color: it is never red or purple. As a rule the other three species named are less robust; *S. magellanicum* commonly is pink or purplish red in color, *S. palustre* pale greenish white, and *S. imbricatum* green.

In this connection it should be emphasized not only that different varieties of sphagnum exhibit a wide range of variation when it comes to their capacity for absorbing liquids, as well as to other features which adapt them to surgical use, but also that the very same species may vary greatly in different localities. Growing under certain conditions it may acquire that soft, "bushy" habit so desirable in material which is to be used for surgical dressings, while growing under other conditions it will be harsh, stringy, and quite unfit for surgical purposes. Even *Sphagnum papillosum* exhibits considerable variation in this respect. And this brings up another question.

Where does the sphagnum grow? In what kinds of habitats does it occur, and in what sections of the country does it develop best?

When it comes to locating sources of supply for surgical sphagnum, obviously it is not enough to be able merely to recognize the sphagnum when you see it. It is not even enough to be able to distinguish surgical from non-surgical material. It is every bit as important to know in what sort of places to look for it, and also what sort of places to steer clear of.

In general, the sphagnums grow in wet places. Taken as a class they are moisture-loving plants. Considering them from a geographical point of view, it can be said that they grow best in regions where the climate is moist the year round, but especially in summer, and where the summers are not too hot. They attain their best development in cool, humid regions, such as Newfoundland, Novia Scotia and New Brunswick, Vancouver Island and Western Washington. On the whole, they develop most luxuriantly near the seacoast, particularly along coasts where fogs are frequent. They are better developed northward than southward. This is especially true of *Sphagnum papillosum*, which has never been found at all south of New Jersey. In the northern regions that I have just mentioned the sphagnums are very widely distributed, occurring not only in swamps but to a considerable extent on uplands as well. Farther south, in regions where the climate is drier and the summers hotter, they are mostly confined to swamps.

Now in this connection, there is one particular type of swamp that I want to call attention to, and that is the kind of swamp known as a *bog*. It is in bogs that the sphagnums develop most luxuriantly. Let us con-

sider first the conditions which prevail in Southern New England, a region in which the bog type is in striking contrast to other types of swamp. The conditions here are essentially similar to those that prevail throughout our Northern States and to a considerable extent in Canada.

The plant-population of all bogs, no matter in what section of the country they occur, is very much alike. In fact, this is so much the case that a bog can usually be recognized from the character of its vegetation alone. Especially striking is the bushy element in the vegetation. Almost invariably this is made up very largely of members of the Heath family: such plants as the bog laurel and bog rosemary, the cassandra, the Labrador tea, and the cranberries. These are mostly absent from swamps of the ordinary description. In Eastern Maine a bog is commonly referred to as a *heath*, although in Maine this word, which in Europe is commonly used with reference to similar areas, has been yankeeized to "haythe." In Europe a bog is also called a *moor*.

The characteristic tree in bogs is the black spruce. Farther north, as in Maine and the Adirondacks, this tree is by no means confined to bogs, but in southern New England it almost never grows anywhere else. Such trees as the elm and the ash, which are common in ordinary swamps, are conspicuously absent from bogs. Bogs are also the home of such bizarre forms as the pitcher plant and the sundews, plants which possess the insect-catching habit. But from our point of view the outstanding feature of a bog is the wonderful development of the sphagnums. Almost invariably they constitute one of the most prominent elements in the vegetation.

To a certain extent the sphagnums may grow in almost any wet, springy swamp, whether it is open or wooded. But in swamps which are situated along rivers, where the ground is flooded from time to time with muddy water, they are not apt to occur in any profusion. Even farther north, in regions like New Brunswick and Nova Scotia, where climatic conditions are most congenial to their development and where they are much more generally distributed than farther south, the sphagnums grow best in the bogs. So abundant as a rule are the sphagnums in this particular type of swamp that many bogs are popularly referred to as *Moss bogs*.

A few words in passing regarding the nature and origin of these bogs. Bogs are perhaps most widely known on account of the deposits of *peat* by which they are commonly underlain. Peat is partly decayed vegetable matter, usually deposited under water. It represents an intermediate condition between dead plants and coal. Coal is essentially petrified peat. In parts of Northern Europe peat is one of the chief sources of fuel, and our own peat deposits have been under investigation by the government for a number of years.

In our region the areas which today are occupied by bogs, almost without exception, were formerly occupied by lakes or ponds. A pond may become filled in and converted into a bog wholly through plant activity. You can find every stage between ponds in which scarcely any filling has taken place and ponds which have given way completely to bogs. Very commonly the filling in is brought about through the agency of what is known as a *floating mat*. The vegetation along the edge of the pond grows so vigorously that it spreads away from the shore out over the open water. In this way there is developed what is commonly referred to as a *quaking bog*. This raft of vegetation, floating on the surface, rising and falling with fluctuations in the water level, may be underlain by clear water or by soft, bottomless ooze. So firm, however, may the mat become that while the surface trembles and quakes when you walk over it, nevertheless it is quite capable of supporting the weight of a man. A quaking bog is an ideal place to look for surgical sphagnum.

In most sections of the United States, bogs are rather rare in their occurrence and they are rather small in size. In cool humid regions, such as Newfoundland, Nova Scotia, and Eastern New Brunswick, they are much commoner and frequently cover extensive tracts of country. In these northern regions, in addition to the ordinary type of bog there is found a remarkable type known as a *raised bog*. Unlike our ordinary bogs, the surface of a raised bog is domed up, just like an inverted saucer. It may be fifteen or twenty feet higher toward the center than it is around the edges. Bogs of this sort are found only in regions where the climate is exceptionally favorable to the development of the sphagnums. They are built up almost wholly by the sphagnum, and they can develop only in regions where there is sufficient rain and fog to permit the sphagnum to grow up above the water level.

Now the facts regarding raised bogs that I have just pointed out have a rather important application. If, as I have said, these raised bogs are restricted to regions where climatic conditions are most favorable to sphagnum development, it follows that you ought to find your best sphagnum in regions where these raised bogs are present. In other words, you can regard the abundance of raised bogs in any region as a sort of barometer as to the degree to which the climate there is suited to the sphagnums.

I have spent a month this past summer investigating the sphagnum situation along the Maine coast. Starting in at Portland, I have visited fifteen different localities between there and Calais, which lies along the Canadian border. In the vicinity of Portland there are no raised bogs, and I was unable to find any trace of surgical sphagnum. As you travel eastward the raised bogs become more and more common, and surgical sphagnum, at first very local in its occurrence, becomes more and more general in its distribution. There seems to be little question that the coastal region of Maine, from Penobscot Bay eastward, is the most promising part of the Eastern United States in which to look for supplies of surgical sphagnum. Unfortunately, however, many of the very best bogs—the ones most suited to the growth of surgical sphagnum, and the ones easiest to get at—lie along the borders of small lakes; and these lakes for years have been dammed by the lumbermen and the bogs flooded to such an extent that most of the best sphagnum has been drowned out. In other places fires have exterminated or killed back the sphagnum over large areas. *Sphagnum papillosum*, the most desirable species for surgical purposes, is extremely sensitive to any change in external conditions. In spite of these difficulties, however, I was able to locate a considerable number of sizeable tracts of good moss; and I have no doubt that others will continue to turn up.

But Maine is not the only part of the East where surgical sphagnum occurs. It may grow in almost any bog. You can only tell by looking. As I stated earlier, American army surgeons at the present time are not using sphagnum to anywhere near the extent that it is being used by surgeons in the other allied armies. But it is our business to be prepared; and to this end we want information regarding every locality which might possibly be utilized as a source of supply for surgical sphagnum. It may be that some of you know the whereabouts of a promising bog. If you do, look it over; and if you find any quantity of what looks like good material, send us a sample of it.[a]

In surveying any district for surgical sphagnum, there are a few practical points which it is well to bear in mind. A wooded bog may contain plenty of sphagnum, but for our purpose it is rarely of any value. The good moss almost invariably grows in open bogs. Again, an open bog, all overgrown with bushes, where the sphagnum forms great soft cushions a foot or so high, is apt to afford pretty poor picking. There may be plenty of moss, but most of it will prove to be of the wrong variety; or if it is of the right variety it will be of poor quality. For that matter, it should be said that in almost any bog there is sure to be a large proportion of undesirable material. Commonly the bulk of the sphagnum will consist of species that are of no use at all for surgical purposes.

The best qualities of moss always grow in the wettest parts of a bog. A dry bog is apt to contain no material whatever of surgical value. A wet one may be full of it. The best kind of a bog for surgical moss is a wet cranberry bog: not one of the artificial variety that is so common in southern New Jersey, but one where the cranberries grow scattered over a soft carpet of moss, intermixed with more or less "cranberry grass" (*Carex filiformis* and *C. oligosperma*) and perhaps a scanty growth of low bushes. It is in bogs of this description that I have seen the best material in Maine. In exploring any bog for surgical sphagnum, always look for the wettest places: the soft, quaky spots around the edges of ponds, the small depressions, and the wet furrows; and steer clear of the bushy places.

In this connection, there is one other important point to be borne in mind, and that is transportation facilities. Any tract of moss, to be of practical value, must be reasonably accessible. It is hardly worth while paying any attention at all to bogs that are situated away off where it will be practically impossible to get material out, even if it is there.

Finally, how is the material collected and prepared for use, and what are the sphagnum dressings themselves like?

The method of collecting and preparing sphagnum for use in surgical dressings, as outlined in Professor Porter's Instruction leaflet,[1] is essentially as follows. For collecting the stuff old oat or potato sacks are used. These are first thoroughly cleaned and boiled. A carefully filled sack is about as much as a man can conveniently handle, particularly where, as is usually the case, there is a considerable stretch of soft, boggy footing between the collecting ground and terra firma. Collecting the moss is not always easy work. In many places the conditions are such that only men can do it, but in other places women and even children can be employed. Under proper guidance, however, this part of the work can very well be performed by laborers. Very likely boy scouts could be used to advantage.

The detailed steps in collecting are somewhat as follows: After selecting a place where the material is as good and as clear as possible, the collector seizes a double handful of the moss, grasping it as low down as possible, and pulls it up bodily. He then squeezes the wet, spongy mass to get rid of the bulk of the water, pulls out any coarse plants that may be present, removes any muck or decayed matter from the bottom, and places the material in a sack. This operation is repeated until the collector has either exhausted the supply or obtained as much as he can handle.

From the bog the sacks of moss are carted to some place where the material can be spread out to dry. The drying can be accomplished by spreading out the moss on a clean lawn or on the floor of a barn or attic where there is a good circulation of air. But where large quantities of material are to be handled, it is customary to use drying racks of some sort. Drying by means of artificial heat is avoided, so far as possible, since material thus prepared is much more brittle than material that has been air-dried.

The only further treatment the moss requires before it is ready to be made up into dressings is sorting over. This is preferably done before the material has become thoroughly dried out, since the moss when dry is more or less brittle and less easy to handle than when moist. All foreign material is carefully pulled out by hand, and at the same time the moss is separated into two or more grades: first class material suitable for dressings, second class material suitable for bed pads, etc. This part of the work, indeed everything except the collection and hauling of material, is done by women. In Canada, moss sorting is one of the most popular phases of Red Cross work among the volunteer workers.

In conclusion, just a word regarding the nature of the absorbent dressings which are made from the sphagnum. The simplest type is merely a bag filled with the moss and then sewed up. This type has been extensively turned out by the Canadian and the British Red Cross and to some extent by the American Red Cross. The bag is made of light-weight muslin, this being used in preference to gauze, which is too light and of too open a texture to use in this style of dressing. This particular type of dressing has several disadvantages. The sphagnum has a tendency to slide around and to bunch up, and the dressing wets through to the back very quickly. Moreover, for various reasons the muslin is inferior to gauze or cheesecloth, such as is used in absorbent cotton pads, and it is objected to by surgeons.

This style of dressing has been greatly improved upon within the last year, and a type of pad has been devised which seems to overcome all of the objections that I have just mentioned. These pads are constructed somewhat as follows: In making the pad, first of all a layer of cheap non-absorbent cotton, the size of the dressing, is laid down. Over this is spread a layer of sphagnum. The cotton backing gives shape to the pad, and it serves to hold the sphagnum in place and to prevent it from slipping around. But in addition to this, being non-absorbent, it prevents the pad from becoming too rapidly soaked through to the back. Over the sphagnum is then spread a double layer of very thin gauze paper, the so-called Scott paper tissue. This is folded under at the edges to form a sort of envelope for the sphagnum. This gauze paper does not affect in the least the absorbing capacity of the pad, but it does serve to prevent fine particles of sphagnum from working through the cloth covering and irritating the wounds, and it therefore makes it possible to use gauze for the outer wrapping of the dressing. Pads of this type are more complicated than those composed entirely of sphagnum, and they are somewhat more expensive. But they are quite easily made, and they are cheaper and at the same time much more absorbent than the ordinary cotton pads.

Sphagnum dressings, however made, are decidedly bulky. In order to flatten them out and to economize

[a] Specimens of material may be sent to the writer at Yale University, New Haven, Conn.

[1] Instructions for the collection and preparation of sphagnum moss for surgical purposes. pp.1-7. Canadian Red Cross, Montreal. 1917.

space in packing, it is customary to run them through a clothes wringer. After this treatment the dressings are ready to be sent to the hospitals, where they are sterilized shortly before being used. Sometimes, however, for emergency use in field hospitals, etc., the dressings are sterilized before being sent out by being dipped in an antiseptic solution.

When the Dog Goes to War*

WITH practically all of the world at war, it is not strange that man should put to use the various qualities that have endeared the dog to countless ages of mankind. The dingo of the caveman has given place to hundreds of new varieties, nearly all of which, but the hunting type, are found in the armies engaged in the European conflict, except that of America. No longer are they used to overcome the enemy by their brute strength, but they are none the less valuable because of their more specialized roles. Even the thoroughbred is out of favor with many who are familiar with the qualities most sought in military circles, because of its greater nervousness and inability to adapt itself to the demands of war. Mongrel types are far more common in the military kennels than anything else, though the Airedale, the German and English shepherd, the old English sheep dog and the heavy Belgian draft animals are present in large numbers. The supply of available dogs is becoming scarce in France and the French Minister of War has written the Director-General of the American Red Star Animal Relief that suitable dogs would be a most acceptable gift to his country.

There seems to be no authentic information as to which army first employed dogs as a part of their fighting force. The Belgians, of course, have for years made large use of a cross between the Mastiff and the Great Dane for drawing their carts and were quick to recognize their peculiar fitness to handle the light machine guns with which their army was well supplied. The mitrailleuse carriage on which these guns are mounted is easily handled by a team of powerful dogs. It is said that through their use many guns have been kept out of the hands of the Germans, even when their drivers were killed, by the dogs rushing back into their own lines trailing the gun carriages after them. Many of these animals are credited with a morose disposition and must be muzzled to be handled with safety.

It was easy to adapt the light two-wheeled gun cart to ambulance work, and now many dog teams are employed to bring injured men to field and base hospitals where their wounds can be attended to.

The retrieving instinct of the dog is employed extensively for searching out the wounded. Germany is said to have several thousand dogs employed in its Red Cross work. France also is using many dogs in like capacity. Thousands of wounded soldiers in this war are said to owe their rescue to the keen scent and ability of these trained animals to search out and discover the seriously injured men who instinctively drag themselves into secluded spots which would be overlooked without the aid of the dogs. These animals are trained to ferret out such cases and bring back some portion of the wounded man's clothing to the hospital aids who follow them back and bring in the wounded men. They are taught to pay no attention to the dead, but those still living are found and the information conveyed that brings about rescue equally as well as though they had the power of speech. For this service no particular breed is required, but only dogs of marked intelligence are employed. In some armies the dogs are taught to take a loose strap, fastened to their collars, in their mouth when a wounded man is discovered, to avoid depriving him of some necessary part of his clothing or foiling the dog through inability to find anything which it can retrieve. Many are the stories which are told of the intelligence displayed by these animals. They are taught not to bark for fear of drawing the enemy's fire. Some of the dogs are credited with having rescued more than half a hundred men—a record which must not be overlooked in passing on their worth for war service.

It was regarded as a good deal of an experiment when France sent over to America and had the champion Alaskan dog racer "Scotty" Allen buy up the best malemutes in the far North and take them over for draft purposes in the Vosges. Their practical worth for bringing supplies and ammunition through the mountain passes was quickly demonstrated and they have become a fixture for this work. A team of dogs will haul a fair-sized load along the narrow gauge tracks that have been laid for this purpose in summer and on the sledges in winter where no other form of transportation could be used. Many of the dogs that had taken part in the celebrated Nome-Candle races are doing their bit today in France as eagerly and willingly as they did to win the first place in those endurance runs.

But it is not merely in draft and Red Cross service that the dogs have justified their place in the European War. As French patrols search through "No Man's Land" to guard against surprise attacks from the Germans, they frequently have with them on a leash a four-legged ally, that by his keenness of scent gives the warning of approaching ranger long before it can be ascertained by the soldier. On the approach of a foe, the dogs are taught to stop in their tracks and point the enemy while their hair bristles up and warns the soldier of his danger. No sound escapes them, not even a growl, that will give the enemy a clue to their position.

In a similar manner they are used in listening posts, and many a raid has been frustrated by their timely warning of danger that the soldiers did not even imagine. At least one dog has been personally decorated with the iron cross by the Kaiser for saving a whole German regiment from ambush.

As a messenger between the firing line and regimental headquarters or artillery positions, the dog has also proven his worth. The dog can deliver a message in three minutes that would take a man ten minutes and do it with less chance of being hit. Not infrequently, when communication between the trenches and the big guns has been cut off by shell fire, the messenger dog has carried a message through safely that has brought reinforcements or has furnished directions that have enabled the artillerymen to redirect their fire and wipe out a troublesome machine gun position or enemy battery.

They also are used to help kill the huge rats that swarm through the trenches and make life at times almost unbearable for the soldiers. As mascots and pets they help to fill in the tedious hours passed by the men in knee-deep mud and thus aid in keeping up the morale of the army. To save the dogs from the effects of the deadly gas to which they are often exposed, special masks are fitted on them similar to those worn by the soldiers themselves.

The French have found an unusual use for dogs that is not duplicated in any of the other armies. The dogs are equipped with a special carrying case for light lunches and hot coffee or cartridges for the men in the first line trenches when the fighting is hot and protracted. They are trained to crawl on their stomachs over "No Man's Land" in order to escape flying balls and reach the fighting men.

The dog pounds of France and the dog breeding associations have long since ceased to furnish an adequate supply. Many of these brave dogs are wounded and killed. Those whose wounds will permit are sent to hospitals especially fitted for their treatment, where they are carefully nursed back to health. France has bestowed the highest decorations within the gift of the country on many dogs that have saved a whole battalion or system of trenches by getting messages through when all other means of communication was impossible.

How many dogs are utilized in this war will never be known until the war is over. Germany has many thousands in service. Italy has a force of dogs with special kennels back of the lines for their housing. England has several hundred employed in various ways. France has 5,000, according to the Minister of War. Belgium makes use of many in maintaining the remnants of its valiant army.

The French Service uses shepherd dogs, drovers' dogs, mongrels, mastiffs, mountain dogs, Airedale terriers, bulldogs, fox terriers and other terriers that can be utilized for the destruction of vermin and mongels of all these breeds. Beagle hounds and setters or those having obviously too much of such blood are of no use. The dogs must be at least one year old. All coats except white are acceptable, and even these may be utilized as guard and defence dogs. Only dogs of intelligence can be used. The French Minister of War states that it would be useless to have dogs trained in America because methods are different and the commands not being made in the same tongue they would have to be retrained in France. Timid dogs cannot be used. Such animals, no matter what may be their qualities, are always afraid of detonations and explosions and for that reason are useless. The classifications of various services in which the dogs are employed is of the greatest interest, as outlined to the American Red Star Animal Relief by the French Minister of War:

1st—As assistants to sentinels, in the listening points, in detecting enemy patrols.

2nd—As patrol dogs, reconnoitering for small detachments, attacking and holding an enemy on the order of their leaders.

3rd—As courier and despatch dogs for carrying messages, in saving the scouts the fatigue and very great dangers of going and coming between the posts of command on the first line in the sectors bombarded or shelled by the machine guns.

4th—As draft dogs; two divisions of Alaskan dogs and their sledges insure in winter the supplying of provisions and military stores and the carrying of the wounded in the Vosges. In summer these animals are harnessed to wagonettes on narrow gauge tracks.

5th—As guard dogs in the storehouses and factories—whether they are trained to attack marauders or to guard a court. This guard system has permitted the reduction of the number of sentinels.

6th—As ratters, for the destruction of the vermin in the trenches, cantonments and storehouses.

It will probably surprise many that dogs can be employed in so many different ways. Much, however, depends upon the man to whom they are assigned. A very good dog can be spoiled in a very few days by a poor handler.

The letter from the French Minister of War throws much light on their training and use, and the extracts quoted from it point out how important the canine service really is. It would seem that a similar branch of service could be utilized equally as well by the American army. Will not the enlistment of the dog be the next step in making our war machinery a complete fighting unit? The *American Red Star* stands ready to do its share in providing dogs and training them for this service.

SYDNEY H. COLEMAN.

*Nat'l Humane Review.

Cork Slabs from Cork Waste

THE cork refuse from making corks for bottles is ground, mixed with resins, pitch, glue, casein, water glass, and other binders and fillers, and compressed to produce linoleum, and cork slabs and bricks for insulation, etc. Cork slabs of considerable strength may also be obtained by compressing the ground waste at 160 degrees C. or 180 degrees C., without addition of any binding agent, and this was ascribed by J. T. Smith, who patented the process in 1892, to the fact that the cork itself contains a resin which is liberated at high temperature and acts as binding agent. From the researches of H. Ost (*Zeitschrift für Angewandle Chemie*, 1918, page 105), it appears very doubtful, however, that this resin is playing any important part in binding the cork particles. By treating cork with alcohol, chloroform, and also with water (which injures the fiber, however), in a Soxhlet apparatus, Ost extracted about 10 per cent of fat, resin, tannin, etc., which formed a brittle solid mass, beginning to melt about 150 degrees C. Preparing slabs of extracted and of natural ground cork by compression at 7 atmospheres of the material at 160 degrees for 20 hours, or at 180 degrees for 3 hours, Ost obtained slabs of a strength of 7 kg. or 8 kg. (even, 14 kg.) per sq. cm., and the slabs from extracted cork were only slightly inferior in strength to the others. Slabs of a certain tensile strength—the determinations were made on a cement-testing machine—could be obtained even at the temperature of 50 degrees C., combined with compression; heating before compression proved utterly useless.

As the pressure increased, the differences between the treated and the untreated cork meal vanished more and more. The compressed cork plates adhered to the walls of the mould (iron, copper, platinum, rough or smooth), but not when tissue paper was interposed, and this paper did not appear to be impregnated with oily resin subsequently. The steaming tests are also against the natural-resin theory. Ordinary cork matting, prepared with binders, is not destroyed by the action of steam. In the absence of binders, steam does cause disintegration of the slabs, extracted or not, unless the compression has been combined with heating to 160 degrees or higher temperatures, and hot alcohol, which is a solvent of the resin, is not more injurious than water in this respect.

Ost's idea is that the strength of the cork slabs depends upon the interlocking and felting of the cork cells. Strongly compressed for a long time, cork (from a champagne bottle, *e. g.*) turns hard and inelastic; the elasticity can be restored by steaming the cork, when it swells again. High temperature, combined with compression, however, destroys this elasticity, the cork grains turn indifferent, and subsequent steaming does not interfere with their felting. The ordinary addition of resinous binding agents to the cork waste surrounds the particles with a skin which is more or less impermeable to water; hence the greater resistance to the disintegrating action of steam.—*Engineering.*

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A squadron of the new light French tanks that are capable of a speed of twelve miles an hour

Mechanical Cavalry

The Tanks That Have Revolutionized Methods of Assault

UNDOUBTEDLY the most sensational development in modern war machines is the tank, not only on account of its originality in conception, but also because of the important results that have followed its introduction.

After the new system of trench warfare had been developed it became evident that attacks on positions well organized in this way, and adequately equipped with artillery and machine guns, could not be carried by any of the known methods of attack except with tremendous loss of men, and even then such attacks could not be undertaken with any certainty. It will be recalled with interest now how in the trench warfare of 1916 weeks of hard fighting resulted in advances by either side of only a few hundred yards; and that it then seemed that the result of the war would be determined by the number of men that either side could afford to sacrifice, and the side whose man-power became exhausted first would become the helpless prey of the other. This was what Germany was anticipating, for its rulers were perfectly willing to squander the lives of their people without the least hesitation if by so doing they could accomplish their own ends, and the result looked dark for the allies.

At this juncture the tank appeared, but although its value was at once demonstrated the time for its full utilization was not then ripe. The tank, which was a British conception, undoubtedly owed its suggestion to the armored car that was widely used in the early days of the war, and which, armed with a machine gun, was found extremely useful in making scouting expeditions and rapid forays against advanced posts. These cars, however, were confined in their operations to fairly good roads, or to comparatively smooth and solid ground; but as the trenches spread their barrier across the land, and not only the roads but the entire countryside became furrowed and gouged by innumerable shell craters, operations by this class of cars became impossible.

The value of what may be termed a mobile, armorclad fortress had however been demonstrated; but it was seen that, under the new conditions of fighting, something more invulnerable against the fire of machine guns, weapons that were then becoming a prominent feature of defense, was necessary, and there

A tank gun used by the British in their large machines

were other conditions incident to trench warfare, such as barbed wire entanglements, which must be dealt with. The happy solution of the problem was the tank, which made its appearance on the battle front late in the summer of 1916. The foundation of the idea was found in the caterpillar farm tractor, then well known in the Western United States; and upon this was erected a little fortress of steel armor plate to protect the crew, the battery and the machinery, and the resulting structure was a massive machine weighing in the neighborhood of 30 tons. These tanks are equipped with an engine of about 100 h.p., which give them a speed of from 5 to 6 miles per hour, and they are manned by an officer and six men. The armament has varied in character, some of the machines having two six-pounder rapid fire guns and four machine guns, while others have been fitted with six machine guns. It is needless at this time to speak of the remarkable work that these unique and formidable monsters of war have done as many detailed accounts of their operations have already been published.

Soon after the British tanks appeared others of French design were reported, which differed considerably in detail from the original models. The first that were built were lighter and faster than their British prototype, and consequently more mobile, and carried a battery of machine guns. Later on the French brought out a larger and more powerful machine, which carried in its front one of the famous 75 cannon, together with a numerous battery of machine guns.

Naturally it was not long before a German tank appeared, they having obtained a knowledge of the construction of the new weapon from some of the British machines that were captured.

The German tanks, which bear the euphonious official name of "Sturmpauzerkraftwagen," comprise three main categories. The first consists of tanks captured from the British in the battle of Cambrai and repaired, or tanks manufactured upon the model of captured British machines. The second type is a German model, smaller than the British tank, but speedier, better armed and more heavily armored. The third class consists of the tanks known as land cruisers, or "large type" tanks. The small, fast tanks are said to be 26 ft. long, 10 ft. wide and about 11 ft. high, with

The fast French Renault tanks

The new light English "Whippet" tank

a weight of 10 metric tons—slightly less than 10 English tons. The land cruiser type is 45½ ft. long, 13 ft. wide and 13 ft. in height. The speed of the German tanks is said to vary between 4½ and 9½ miles an hour.

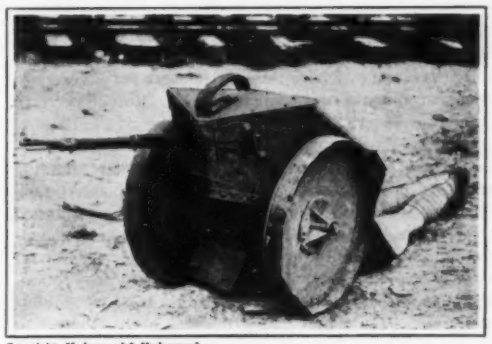
Their armament consists of guns—doubtless the shortened 77 m.m. weapon—machine guns and liquid flame throwers. The latter is an innovation which must add considerably to the efficiency of the tank for the purpose of clearing trenches, as the machine can obviously carry a far greater reservoir of combustible liquid than a single soldier. It is said that the Germans have introduced certain improvements in tank construction designed to give heavier protection against artillery. The crews are also able to close the machines hermetically when passing through gas clouds. The German tanks are organised in squadrons commanded by majors. The officers appear to be volunteers and men chiefly specialists—motor mechanics, gunners, or machine gunners.

From reports that have been published it would appear that the German tank is not as well built, nor as efficient as those of the allies, probably on account of lack of suitable material, and this is particularly apparent in the armor which is of inferior quality, and consequently a much greater weight has to be carried.

One of the shortcomings of the first tanks was their slow speed, which not only worked against their successful use in surprise operations, but moreover made them an easier target for field guns, against which they could not carry sufficient protection. To meet this difficulty, and to provide a weapon that could be used more universally in rapid offensive operations, in concert with infantry, both the French and the English have produced a light-weight, fast tank which has a speed of about 12 miles an hour, and requires a crew of but two men.

The new French tank, known as the Renault from its makers, weighs but 6 tons, and is powered with a 40 h.p. Renault engine. Its armament is either a machine gun, or a 37 mm. (1½ inch) quick firing cannon, which is mounted in a turret that can be revolved through a full circle. A unique feature of these little French machines is a projecting, curved

A captured German tank



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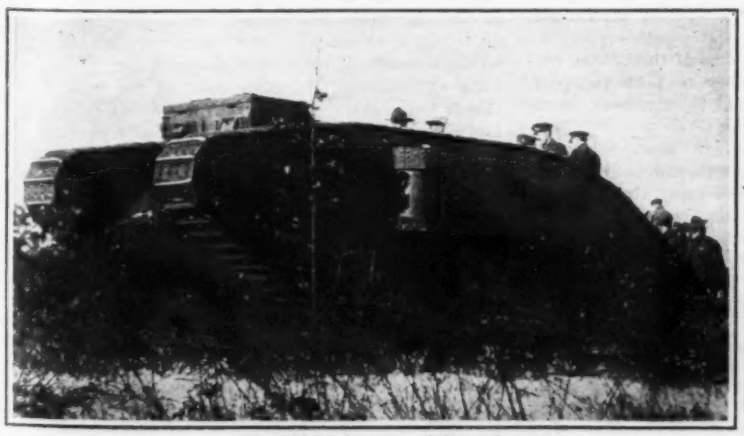
A German one-man crawling tank

tail piece that enables them to climb almost vertical inclines without tilting over backwards. The English "Whippet" is of a similar character to the French Renault, and is supposed to carry a six-pounder quick firing gun. These two fast moving tanks have, in the sensational advances of the late summer and fall, operated with the cavalry far in advance of the infantry, and have proved invaluable in wiping out machine gun nests and routing batteries of field guns, while to the heavier machines has been left the more arduous task of reducing more strongly fortified positions and rolling out the acres of barbed wire entanglements that have been found practically impenetrable by infantry alone.

To meet the attacks of tanks the Germans have devised a monster rifle of the same kind as carried by the regular infantry, but over six feet long, and weighing about 37 pounds. It fires a cartridge nearly 5 inches as long as those fired by an ordinary rifle, and its bullet is supposed to be capable of penetrating armor of the thickness usually carried by the tanks. On our side, an American anti-tank gun has been brought out that is believed to be very effective. This is a quick fire gun of 37 mm. bore, and only 32 inches long, firing an armor piercing shell that is capable of creating great havoc in any machine it is brought against. The principal means of meeting tank attacks, however, is by means of bombs or liberally planted mines, for if a sufficiently heavy charge can be exploded under one side, and the tank toppled over, its activity is terminated.

When the British brought out their first tanks they provided them with a pair of flanged wheels at the rear to serve as a rudder; but not only did this arrangement apparently prove inefficient, but it was very liable to injury; so in the later machines the mechanism was so arranged, by means of properly located clutches, that the caterpillar driving belt on either side could be thrown out of gear with the engine. With one belt stationary, and the other being driven, the tank could be turned in a circle but slightly exceeding the length of the tank in diameter. Probably all descriptions of tanks are now provided with gearing giving more than one speed; the Renault, for example having four speeds ahead and a reverse, making it highly mobile and easily handled under any conditions.

Without the tank the wonderful offensive of the allies would probably have been far slower, if not impossible, and the loss of men far greater. As a means for successfully attacking the various concrete "pill boxes" and fortified dug-outs, as well as clearing out difficult trenches the tank has proved the salvation of the allies, and as long as we can maintain our superiority in this equipment no line of defences can survive.



The British heavy-weight tank

A heavy French tank

Die-Casting of Aluminium-Bronze*

By H. Rix and H. Whitaker, M.Sc.

DIE-CASTINGS may be defined as "finished castings, made by pouring molten metal, flowing by gravity or under external pressure, into a metallic mould."

Advantages of Die-Casting.—Some of the advantages of die-castings are:

1. The accuracy and uniformity of the castings. They can be made to specification 0.005 per inch, or even less for small parts.

2. Machining costs are either eliminated altogether or are greatly reduced.

3. The process is continuous, and the output is generally much greater than is the case with sand-casting.

4. Articles which it would be impossible to sand-cast may be successfully die-cast.

Although the process has been in operation for over twenty years, it is only during the last ten years that it has assumed importance as a separate industry, and this is largely due to the development of the automobile and aeroplane.

Metals Employed.—The alloys employed may be divided into five classes, according to whether the principal constituent is (1) zinc, (2) tin, (3) lead, (4) aluminum, (5) copper.

Owing to their low melting-points, alloys of the first three classes were initially employed, but the castings lacked strength and rigidity. An average zinc base alloy has a tensile strength of about 8 tons per square inch, with practically no ductility, but these alloys are very liable to corrosion and distortion.

The tin and lead-base alloys include a large number of the "Babbitt" or bearing metal type, and many bearings are now being die-cast.

The low specific gravity, cheapness and strength (when alloyed) of aluminium, have been the principal factors in its development as a die-casting metal. The chief drawbacks are:

(1) Its high melting-point (compared with lead, tin, and zinc).

(2) Its tendency to attack iron when molten.

(3) Its high shrinkage.

(4) Its weakness at high temperatures.

On account of (2) the "plunger" type of machine has been largely superseded by one employing air-pressure, or by utilising the pressure of the riser or gate. A die using zinc-base alloy lasts almost indefinitely, but, when using aluminum alloys, cracks begin to show after 2,000 or 3,000 castings have been made. The high shrinkage of aluminum has been reduced by alloying, and need not exceed about 1.4 per cent.

The weakness of the alloys at high temperatures is responsible for the formation of cracks which develop while the metal is solidifying in the mould. Thus the strength of the copper-aluminum alloy containing, say, 12 per cent. copper drops from 8 tons to 10 tons per square inch at 0 deg. C. to 3 tons to 5 tons at 350 deg. C.

Notwithstanding these drawbacks aluminum alloys of very variable composition are being successfully die-cast on a large scale.

Brass and Bronze Die-Casting.—The next step in the process was to surmount the difficulties connected with copper-base alloys, which have a much higher melting-point. The literature on the subject is as yet very scanty, but most of the workers in the field express the opinion that brass or bronze die-casting is almost a commercial impossibility. On reading the accounts of the work done by the Doehler Die-Casting Company,[1] Work,[2] Webber,[3] Schulz,[4] Pack,[5] and Norton,[6] one arrives at the following conclusions:

1. The chief difficulty in the process is the high temperature (900 deg. to 1,000 deg. C.) for casting "yellow metal." This has several effects. The zinc in the brass attacks the steel die,[6] which rapidly deteriorates, so that no more than 1,000 castings can be obtained. The high shrinkage of brass sets up strains within the die which further impair its accuracy. Since the die cost (anything from 5*l.* to 200 *l.*) is the prime factor in die-casting, this is a serious matter. For the same reason it is impracticable to use an iron container for the molten metal, as the alloy would rapidly become contaminated thereby; hence air pressure cannot be employed to force the metal into the die. This means pouring from the crucibles, with consequent slowing down of production, if (as is often necessary on account of expense) only one die can be used. Another consequence of the high temperature and slow pouring is the large amount of dross which is formed. Also ordinary brasses are not sufficiently strong at high temperatures to withstand the shrinkage strains which are set up.

2. It is very difficult to produce brass die-castings which are consistently free from blowholes or shrinkholes. The former are caused by air being entrapped in the mould, and they cannot be overcome by simply increasing the pressure in the mould or by carrying out the process *in vacuo*. By a careful study of the venting and gating of each part, however, this unsoundness may be practically eliminated.

3. Brass and bronze die-castings are only a commercial success if the parts cannot be completely produced by automatic machinery, or when they obviate numerous difficult machining operations, involving different settings of tools. To compete with the machined products the die-castings must be rapidly made, must be accurate to within ±0.002 per inch, and must have a smooth polished surface. Recent developments in foundry and machine shop practice have made it possible for many parts to be now more cheaply sand-cast, and "yellow" metal die-casting is "practically restricted to pieces of fairly simple shape, weighing btween ½ oz. and 3 lb."

The experiences of the authors in this connection have been chiefly in the use of brass (60:40) containing about 2 per cent. aluminum; manganese brass; and "aluminum-bronze" containing iron. In the first case, the aluminum is added to give fluidity to the metal and better definition to the castings. In the second case manganese brass of usual composition is used, containing less than 1 per cent. manganese, with a little iron and aluminum. The chief objection to these metals is that the surface of the die becomes rapidly covered with a coating of zinc oxide, which must be brushed off after every cast or the definition is spoiled. Various methods have been tried to overcome this difficulty, but so far without complete success. Our best results, however, have been obtained with "aluminum-bronze" containing iron. The first alloys experimented with were of copper-aluminum containing about 10 per cent. aluminum, the balance being copper. The results were disappointing, for the metal did not lie so "kindly" to the surface of the die as it might have done, and the definition of the edges was poor. After repeated trials it was decided to add a little iron, when much better results were obtained.

In their masterly research on the copper-aluminum alloys Carpenter and Edwards' brought the investigation to a point "where the way is clear for investigating the influence of a third metal." Rosenhain and Lantsberry,[8] in their introduction to the Ninth Report, discuss the reasons which led to the selection of manganese as the third metal, and it is rather singular that iron does not seem to have been considered as even a possibility. Vickers[9] alludes to the prejudice which appears to exist in the minds of most foundrymen against iron in copper alloys, probably due to its harmful effect when present in brass in any quantity. He also states that the use of iron in "aluminum-bronze" is no new thing, but has been common in Germany and the United States for some years. While claiming that it improves the metal for sand-casting, he questions its use in die-casting, for the following reasons:

1. In sand-casting it is necessary to add iron in order to prevent the "excessive crystal growth" which is "such a drawback to the 10 per cent. aluminum-bronze."

In die-castings this is not necessary, as the chilling effect of the die is sufficient to keep down this growth.

(That the iron has this effect was shown by Corse and Comstock.[10] Combined probably with aluminium and copper the iron is the first constituent to separate out, in the form of small black crystallites, which form nuclei round which the α-solution crystallises, thus reducing the grain size.)

2. Iron accentuates the shrinkage of the bronze, consequently increasing the tendency to form the pear-shaped cavities commonly found in aluminum-bronze die-castings.

The authors do not agree with the above conclusion limiting the usefulness of copper-aluminum-iron alloys to sand-castings, having produced many thousand die-castings in these alloys. The cavities referred to are certainly a difficulty to be overcome. They are either shrink-holes, caused by the large contraction of the metal, or blowholes caused by air being entrapped in the die by the molten metal, and they may be detected in a casting by finding its specific gravity. Their direction is often radial, and they may be colored black inside. In either case, they may be practically eliminated by a careful study of gating, venting, &c.

Tetmajer[11] has worked with "aluminium-bronze" containing iron and silicon, but what appears to be the most complete account of the copper-aluminium-iron alloys is by Corse and Comstock.[12]

They have studied the properties of the possible combinations containing 1 per cent. to 4 per cent. iron and 7 per cent. to 10 per cent. aluminium inclusive. Their conclusions are that "for the same aluminium content there is always an increase of proportional limit, yield point, and ultimate tensile strength with increasing iron content, and in general a rather less substantial decrease in elongation and reduction of area. In the same way, with constant iron content, the proportional limit, yield point, and ultimate tensile strength increase with increasing aluminium, while the elongation and reduction of area decrease. Also, that for a given strength, better ductility can be obtained with a lower aluminium and high iron alloy, than with higher aluminium and low iron."

It is, of course, difficult to compare the results of different workers on similar alloys, owing to lack of uniformity in methods of preparation and testing, but a comparison of the results contained in the Eighth and Ninth Reports to the Alloys Research Committee, and those obtained by Corse and Comstock, leads to the following conclusions:

1. Iron and manganese, when added respectively to copper-aluminium alloys (containing 7 per cent. to 10 per cent. aluminium), have a similar effect, *i. e.*, the yield-point and ultimate tensile strength are raised at the expense of the ductility.

2. In the case of sand-cast bars, the addition of iron appears to give better all-round mechanical properties than the addition of an equal amount of manganese. The data are not available for a complete comparison of the chill cast bars, but some promising results have been obtained by the authors with alloys containing 7 per cent. to 10 per cent. aluminium and 1 per cent. to 4 per cent. iron. The authors are producing die-castings commercially in one of these alloys, and the following are the average results recently obtained from 24 test bars, cast in 1-in. chill and cooled in air:

It should be pointed out that each bar represents a batch of castings, produced consecutively during a period of several months, under ordinary foundry conditions.

Diameter of Test-section.	Yield-Point.	Ultimate Tensile Strength.	Elongation on 2 In. per Cent.	Reduction of Area per Cent.
in. = 0.564	tons per sq. in. 14.7	tons per sq. in. 33.5	24	21.8

These results compare favorably with those for the chill cast bars containing 7 per cent. to 10 per cent. aluminium given in the Eighth Report, and for those containing 8 per cent. to 10 per cent. aluminium and 1 per cent. to 5 per cent. manganese given in the Ninth Report. In several cases the latter alloys give better results, but whether they may be die-cast or not is open to question.

Heat Treatment.—The mechanical properties of the copper-aluminium-iron alloys may be profoundly modified by heat treatment, and this probably accounts for the variable results obtained with the same metal under ordinary casting conditions. Consequently, accurate pyrometric control of the die-casting process is advisable, if consistent results are required. The temperature of the molten metal should be known, and that of the die itself, also the rate of cooling of the hot casting should be standardised. Much different mechanical properties would result if instead of quenching the casting red hot from the chill, in cold water, it were allowed to cool slowly in air.

An advantage of the alloy used by the authors is that it is sufficiently fluid to fill the die and give satisfactory castings through a wide range of temperature.

Material for Dies.—The authors have experimented with several materials, ferrous and non-ferrous, for die-making, but have had the best results with a close-grained cast-iron, as hard as is consistent with good machining properties. The block of iron from which the die is made is itself chill cast, to give these qualities. Sometimes the dies have been cast almost to shape before machining, but the results have not been very satisfactory.

It need not be pointed out that a die when once

*Paper read before the Institute of Metals.

[1] Doehler Die-Casting Company, Brooklyn, N. Y.

[2] *Mechanical World*, October 8, 1915.

[3] *Machinery*, January, 1916.

[4] *Mechanical World*, July 21, 1916.

[5] Transactions of the American Institute of Metals, 1914 and 1915.

[6] *Ibid.*, September, 1914.

[7] Carpenter and Edwards, "Eighth Report to the Alloys Research Committee," 1907.

[8] Rosenhain and Lantsberry. "Ninth Report to the Alloys Research Committee," 1910.

[9] *Mechanical World*, August 17, 1917.

[10] Transactions of the American Institute of Metals, September, 1916.

[11] *Mitteilungen der Material-prüfungsanstalt*, IX Heft.

[12] Transactions of the American Institute of Metals, September, 1916.

made is only suitable for one particular alloy. Each alloy has its own requirements regarding gating, venting, and shrinkage, and the particular problems of each new part render it very difficult to make a correctly designed die at the first attempt. In an iron die as described above, there can be made from 5,000 to 7,000 castings similar to a "Butterfly" type of carbon brush-holder that was shown before it shows signs of deterioration. No facing or special treatment of the die surface is necessary, nor is the die cooled down every few minutes; but the plugs, which are of steel, are dipped in a graphite wash between each cast to preserve their shape; even then they do not last so long as the die. The design of the die is a most important factor, and here it is where experience is the best guide. The design of the part itself should conform to the special requirements of die-casting, and there is need for the closest co-operation between the engineer, metallurgist and foundry foreman. The number and shape of the part of the die, method, and order of withdrawing the cores, venting, situation, shape and size of the gate, all must be carefully considered in designing a new die.

Cost of Process.—No general rule can be laid down with regard to costs. In some cases die-casting is cheaper, in other cases dearer than sand-casting. The cost of dies, material, labor and machining must be gone into before a decision can be come to as to which is the more economical process. The cost of machining and assembling of the "Butterfly" type brush-holder above referred to is eight times as great when sand-cast as it is when die-cast, and the other parts shown are also cheaper die-cast. The castings are not sold by weight, as the cost of labor varies both in making the dies and castings. The die cost is treated as a separate item from that of the castings, and is generally borne directly by the customers.

Die-Casting on a Scientific Basis.—For a scientific investigation into die-casting, the following might be carefully studied:

The alloy:

(1) Coefficient of expansion at different temperatures.
(2) Specific heat.
(3) Thermal conductivity.
(4) Mechanical properties at high temperatures.
(5) Mass, volume and surface area of casting.
(6) Latent heat of fusion.
(7) Metallography.
(8) Pressure on metal in die.

The die-material:

(1) to (5) As above.
(6) Possible attack by molten alloy.

Casting conditions:

(1) Temperature of molten metal.
(2) Temperature of die.
(3) Length of time in die.
(4) Rate method of cooling of casting.

Even with all the above information, however, it would still be necessary, in the case of a new part, to go on more or less empiric lines before a satisfactory casting could be produced.

It might be feasible to design a standard die which would serve as a basis for comparison of results obtained by different observers.

Conclusion.—One of the authors previously quoted summarises the position by saying that "the principal secret of die-casting is experience, which is the result of tireless effort, skill, patience and—capital."

The thanks of the authors are due to the British Westinghouse Electric and Manufacturing Company, Limited, for permission to publish the above paper and the accompanying photographs.

A Nursery of Broken Ships

In the sheltered roadstead of an old Channel port lies a strange fleet of merchantmen. Not ghosts are they, nor ships of other days; there is nothing in their design or rig to suggest quaintness or age. They are substantial vessels, every one of them, and at first sight the only noticeable things about them are the generous anchorage allotted to them and their deep draught and uneven trim, as if they had just come from overseas bearing in their holds the garnered treasures of the East and West for the sustenance and comfort of these islands. That, indeed, is true in part, but it is not the real reason why in these days of feverish shipping activity such fine vessels should lie at anchorage dreaming through the long summer day and rising and falling gently with the tide.

What, then, are they, and whence come they? They are those that have risen from the dead, clutched, as it were, from the vast grave of the sea, beached and salved, brought into port and repaired, and after many weeks sent forth again fully restored to health and in their old seaworthy condition. Here, as at other repairing ports, the damaged ships must wait their turn to enter dry docks, and so they linger through these pleasant midsummer days at anchor, being repaired as far as possible, discharged, refitted. Only their sturdy bulkheads keep them afloat; one or two were carrying as much as 4,000 or 5,000 tons of green seawater in their holds, and others had nets spread over their gaping wounds to prevent the tide washing out their cargoes. To the ordinary marine risk—in these days of circuitous routes, screened lights, and unlit coasts, more than usually grave—is added the murderous menace of torpedo and mine, with collision and fire as grim corollaries. Hence this fleet has suffered violence in many shapes and forms. Undersea damage, if the most serious, is not the sole arresting agent of a vessel's usefulness. It may be that collision has staved in the bows, or that fire has buckled the deck plates and made a fiery holocaust of the superstructures. Risen from the dead, indeed, are these ships, and the loving care and patience bestowed upon them by their salvors all round our coasts has saved this nation millions of tons of carrying capacity, millions of tons of cargo, and millions in hard cash.

That is no idle figure of speech. There is nothing of exaggeration here, but only sober fact. Since the War began, actually millions have been saved to the country through the work and activities of the Admiralty Salvage Department, which, since 1914, has been evolved by our naval authorities from the nucleus of the Liverpool Salvage Association. Captain F. W. Young is the very capable director of this important naval sideline; he is, by general consent, recognised as the leading salvage expert, not merely in this country, but in the world. It may be a debatable point whether it was wise to concentrate salvage activities around our long coast line in one central authority, instead of marking off a particular stretch of seacoast to the salvors best acquainted with its configuration and tides; but no one will be found to dispute the enormous success that has attended, and now attends, the work of the Department. Since October, 1915, over 400 merchant ships have been restored to service through its agency, and, while it is true that Government backing has alone made this possible, the enormously enhanced value of tonnage justifies the expenditure and explains the development in plant and personnel. Naturally, too, this tonnage scarcity incites our salvage men to do their best to beat the worst the combined efforts of the elements and the enemy can produce. Accordingly, under naval auspices, has been rapidly assembled a salvage plant and fleet never before seen at work on the sea or under it; experts from the four quarters of the Kingdom are at its beck and call; and ships which before the War would never have been looked at by a ship-repairer, and, at best, would have been sold for scrap iron, are now taken in hand and given another opportunity to defy fate and piracy. Here in this Channel port one heard the kindly familiar burr of the Tynesider, and learned without surprise that Tyne ship-repairers are now working on some of the toughest jobs in ship salvage ever attempted by mortal man. . . . In the evening, in places where men most do congregate, we heard talk of Smith's Dock Company, and of the relative merits of Northeast Coast and Merseyside salvors. I do not pretend to decide between them.

The element of danger is always present in salvage work under any conditions, and not infrequently an element of romance as well. Indeed, I am not sure that romance is ever absent from such work; the enthusiast assures me it is not. There is extraordinary variety in it; and shipping men do not need to be told in detail what such variety consists of. But it should be understood that many new appliances have been successfully adapted to salvage work within the past three or four years, and the *modus operandi* has been profoundly changed, if not almost revolutionised, since 1914. Of course, the bulkhead remains the one great factor of safety and floatability in the modern vessel; without it most of our ships of today would be lying at the bottom of the sea after being dealt with by an enemy submarine. But the "Admiralty patch" is another and quite recent development of salvage ingenuity. As we should expect, less is known about this standard patch for repairing torpedoed vessels than about bulkheads. That should not be, for in one respect this invention is among the most important of the improvements effected in salvage work by reason of the War. It is perhaps no secret that it evolved from the fertile brain of Captain Young himself. It was found that when vessels managed to reach port after being torpedoed the work of putting them into a condition to be taken to a repairing port was so tedious that something special had to be done, and the result is shown in the salvage patch now in use. With this patch it is possible to repair a vessel with the broken side under water, and after pumping out the holds she can steam to another port. If the engine room is damaged the vessel can be towed in perfect safety. Not only does this invention allow cargo to be salved and landed quickly, but it enables an enormous amount of time to be saved, so that repairs may be effected and the vessel put again into commission. The saving to the country is thus enormous. One patch we inspected was probably the largest yet used. It weighed 20 tons and was 48 ft. by 25 ft.

As remarkable in its beneficent work in saving valuable tonnage is the submersible electric motor pump which the firm of the Submersible and J. L. Motors, Ltd., of Southall, Middlesex, has so successfully specialised in and has done so much to develop. To put it briefly, the use of such pumps enables salvage operations to be conducted in depths of water hitherto unattempted and in "unget-at-able" holds. This ingenious patent can be lowered down to any decks below water, or even suspended by wire rope and pulley between them, and worked from the generators of the salvage steamer either alongside or from any distance away. In the event of bad weather coming on it is only necessary to disconnect the wires, and the pumps, being under water, well down in the hold of the ship, will be in comparative safety, and can be started again immediately the weather moderates, by again connecting up the wires.

Again, one of the greatest troubles the modern salvage expert has to contend with has been the accumulation of gas in the holds of sunken vessels, due to decomposed vegetable matter, decayed meat, etc., and divers and others assisting them in the course of salvage operations have sometimes lost their lives. In one particular case four men were overcome by gas. The gases caused by grain give a lot of trouble, for grain develops sulphurated hydrogen, which causes semi-blindness and violent sickness, and turns everything a leaden color. A chemist has, however, made an extraordinary discovery during the War which kills immediately these gases, and the salvors are now able to carry on their work freely as soon as the presence of the gases has been discovered and the rotting cargoes have been sprayed with the preparation. We know of what we write, for the pungent odor of these awful gases and powerful antiseptic still clings to us here in London.

Something of all this a number of us saw in our week-end tour of inspection among these lame ducks of the sea. To the landsman's unskilled eye and sense it almost appeared as if many of the ships were scarcely worth the saving. But to the salvor probably the greater the difficulty and the graver the risk, the more important it had become to pluck the ship from the greedy embrace of the sea. And so, up and down our coasts, in sheltered bays, on exposed reefs, or by rock-bound shores, the work of reclamation goes steadily on, undeterred by enemy risks, and only temporarily checked by tide and gale. Many thrilling stories can be told of all manner of ships thus restored to usefulness, each seemingly more wonderful than the other: but to single out one is to blur the perspective of the whole. Enough to know that all round our shores this stupendous salvage work proceeds without ceasing, keeping our ship-repairing yards extremely busy and minimising to an extraordinary, and almost unbelievable, degree the foul practices of the enemy submarines and their piratical crews. Assuredly the Salvage Section of the Admiralty deserves well to be remembered when the time comes for summing up the forces which even now are giving us victory over the enemy.

—From *The Shipping World.*

Uvachromie, a New Method of Producing Colored Photographs

In a lecture at the Technical College, Munich, Dr. A. Traube read a paper on the production of colored photographs by a process which he calls "Uvachromie." Three photographs are taken through suitable color-filters, the negatives being copied on ordinary kinematograph films. After fixing, these films are treated in a bath so as to form a chemical compound that readily absorbs color material. The three component pictures can be colored and dried in about twenty minutes, and they are then placed in register upon one another, and the colored photograph is complete. The new process has the advantage that as many copies may be made as are required, the process being rapid and simple. The photograph retains its sharpness of definition, and corrections in color can easily be made by replacing one or other of the component films in the color solution for the appropriate length of time.—*Nature.*

The Zeppelin Biplane*—I

A Description of a Monster German Bombing Machine of Recent Construction

By Jean Lagorgette

M. JEAN LAGORGETTE has, one is glad to say, contributed to *The Aeroplane* the following valuable description of the first German "Giant Aeroplane" to fall into the hands of the Allies.

His drawings are a reconstruction of the wreckage of one of these machines, and he has furnished with the drawings a description considerably more elaborate than those which have so far been published, and sets forth an identity hitherto unsuspected concerning the character and construction of these machines. M. Lagorgette writes as follows:

THE "LIZENZ" JOKE.

On June 4th, 1918, a giant German aeroplane was captured on the French front. This has been called by various papers "The Lizenz" type, and it has been described in a manner which entirely lacks exactitude. It is true that some months before in a single night two at least of its relatives loaded with bombs of a thousand kilogrammes were lost at sea in the course of a raid by six similar machines on the English coast, but the one described is the only specimen of these famous "Dreadnoughts of the Air" in the possession of the Allies at the time of writing.

When captured it was in a sufficiently bad state, as photographs published in the illustrated papers have shown. Burnt by its crew, broken, and copiously pillaged in the customary way, then transported in pieces, some perseverance has been necessary in working out the reconstruction of this immense carcase—a new Diplodocus—of which the vertebræ were considerably deformed. This reconstruction differs quite considerably from previous descriptions, but so far as it goes, except perhaps for some intimate details, I guarantee its rigorous exactitude.

As to those fanciful publications, the least that one can say without exaggeration is that for so many words, figures, and characteristics, there are an equal number of gross errors.

*An abstract of a paper published in *The Aeroplane*, London.

First of all, as regards its name and place of birth, on the faith of vague information they have talked of "Lizenz Avions." It was assumed that the captured avion had been constructed by the "Lizenz Company," an unknown firm, newly born, which as an initial essay had succeeded in producing this colossus where better prepared establishments had failed. This would have been as singular as if an avion had been designed by "Monsieur Brevêt," or as if railway carriages had been built by the well-known firm "Smokers."

It therefore seems probable that this quaint avion has been conceived and designed by a certain firm and has been constructed "under licence" in another workshop, as is commonly the case in Germany where workshops deprived of their own personal models are obliged to construct models accepted in small numbers by the Authorities, following the tendency which is becoming general in France since there has been an attempt at the unification of types.

THE REAL ZEPPELIN.

But who, then, was this mysterious firm of which the name has never yet been pronounced? I affirm as certain that the whole business is concerned with a Zeppelin aeroplane constructed by the Albatros firm. It is not, therefore, by way of metaphor that I describe these "New Zeppelins," these giants of the air, and anyone can without fear of error substitute the name "Riesenflugzeug-Zeppelin-Albatros," or briefly "Zeppelin," for the anonymous appellation of the giant aeroplane.

Therefore, henceforth "Zeppelin" will signify an avion (aeroplane of war) more often undoubtedly than dirigible balloon, for the manufacture of the latter is being slowed down even for the German Navy. Let us remark in passing that no one would be better qualified than the Zeppelin firm to proclaim in this indirect but formal fashion the fallibility of the colossal balloons, hitherto the pride of Germany—at least for the present epoch, and, above all, in view of the needs of war, even over the sea.

It does seem to me doubtful that this model of giant avion has been made the object of a patent by the Zeppelin firm.

This deduction is corroborated not only by the colossal scale of the avion, but by the amount of aluminium which is employed therein. By this word one designates here all species of duralumin, used not only in sheet and in tube, but in U-shaped bars, as well as in certain particularities and forms of construction, such as ribs of aluminium, girder-work in the fixed tail-planes and fins, and in all the control planes.

Even the zig-zag disposition, although in wood, used in the wings and in the tail-plane, the mode of fixing the cables and struts of the wings and the cabane, and of the fuselage, as well as in many details described hereafter, indicate Zeppelin construction.

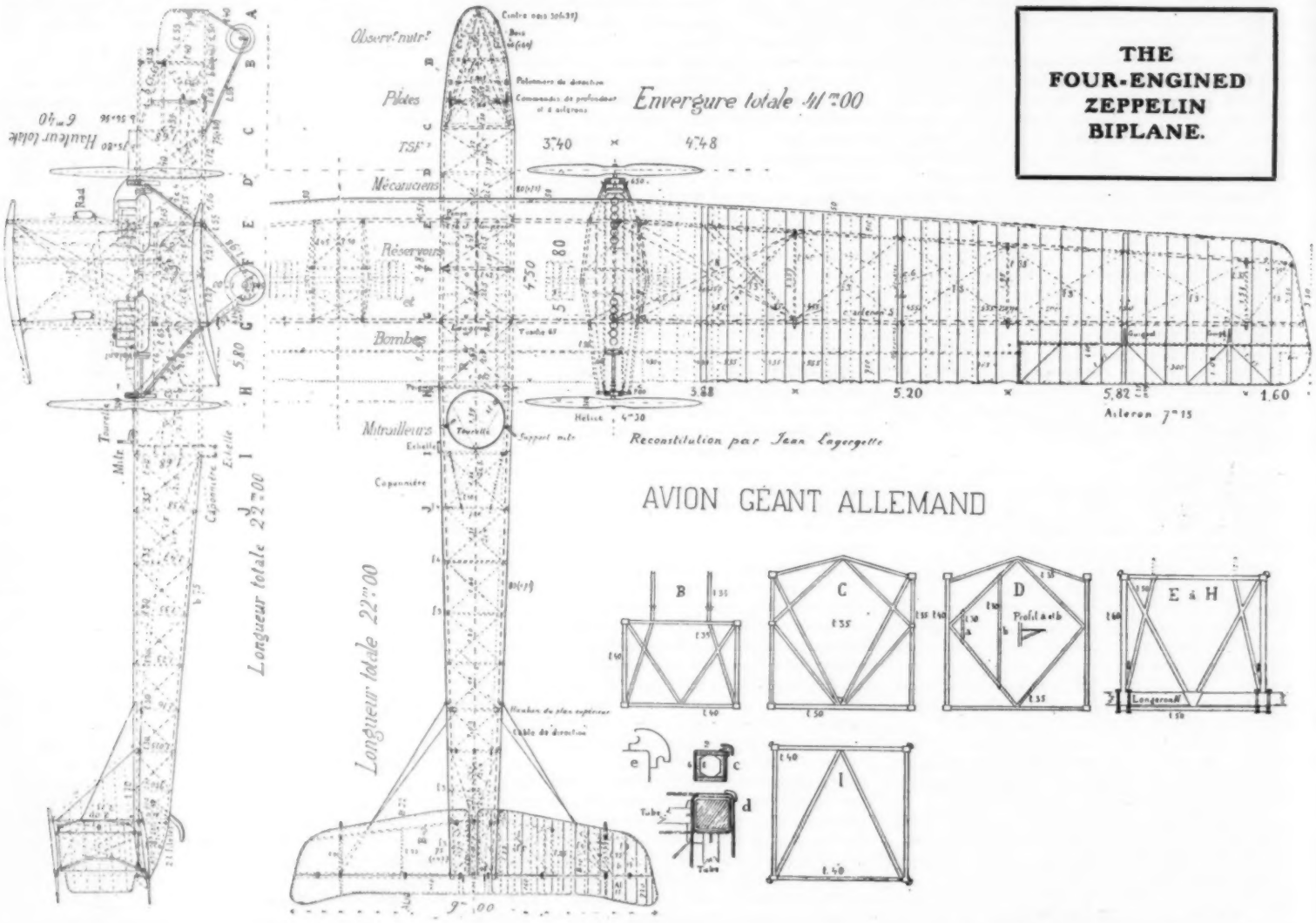
It is probable that the first of the giant avions was tested at the beginning of 1917, near Friedrichshafen on Lake Constance.

THE ALBATROS SHARE.

I consider, on the other hand, as absolutely certain that the captured example was constructed and assembled at least to a considerable extent, if not totally, not in the Zeppelin workshops, but under licence in the Albatros works.

There are many different details of the wiring which employ Albatros fittings which have already been described in the account of Albatros machines in previous issues. These same fittings are also found in the ribs of the B.F.W. type C.5.

The captured avion was constructed in July and August, 1917. Its controls carry the date of reception, August 11th, 1917, but it is possible that it has been tuned up, repaired, and even somewhat modified, as the structure of the undercarriage and its inscription "Verstärkt" (re-inforced), as well as various other details, tend to prove.



THE FOREKUNNERS.

At this point one must protest against the epithet of the "first giant avion" which has been allocated to this machine. When insisting on the origin of the conception of giant aeroplanes and hydro-aeroplanes, the construction of which was tried in France before the war and afterwards in America by Curtiss, let us indicate that Mr. Handley Page has not only foretold the use of giant aeroplanes, but that he has erected them according to a regular system.

Caudron, Caproni, Handley Page and Sikersky—the last-named with his four motors transversely in line—have among the first realised the giant war machine. Biplanes and even triplanes, the instruments of many exploits of all sorts, and the actual Zeppelins, as well as the Gothas, I repeat, owe much to these machines, notably to the Handley Page, one of the first of which had the bad luck to land at Lille on its way from England, and also among others to the twin-engined Spad with its screws behind, which was tried in 1916.

The powerful three-engined D.N.F. (Duperron, Niepce, Fetterer) and the twin-engined Bréguet made their trials a long time ago—this is mentioned only to recall the past. Also the Germans have certainly not been ignorant of the tests of Voisin, who, on various occasions, has had different types of multiplanes flying over Paris and its environs, machines with a span almost equal to that of the Zeppelin; with motors very similarly disposed, and ceding nothing to the German monster.

It is then only in the use at the Front, and not in the construction, or even the efficiency of machines only a little larger than the Handley Page, that the Germans have been ahead of us. The Germans give up everything in the search of colossal "effects," and, besides, never neglect a chance of appropriating the ideas and innovations of others. Also the differences in dimensions are less than first accounts supposed, and the qualities of the Zeppelin appear much more mediocre than those which were attributed to it.

AN OVER-RATED COLOSSUS.

As to the realisation itself, as one has previously observed apropos the big twin-engine machines, the Germans have only enlarged the dimensions without venturing into the unknown, or into the original. Their Zeppelin has hardly anything peculiar to itself except its enormousness.

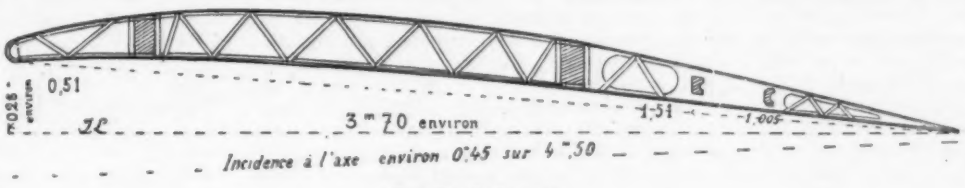
They have not revolutionised or even renovated their general conception of avions. Working on what existed, functioned and had passed its tests already, they have never executed any prodigious step forward, but have, on the contrary, merely effected transitions.

Their twin-engine machines do not disclose any new conception, either national or personal. They have only enlarged proportionally, and, so to speak, photographically, their single-engine machines. The analogy is striking when the same firms construct at the same time single-engine and twin-engine machines. For example, the twin-engine A.E.G. of the 1916 type, still in use, and the single-engine A.E.G. of 1916, have many similar characteristics, as, for instance, the balancing of the ailerons and the rudders on the twin-engine type.

Save for racial innovation, it is in this sense of an evolution, less rapid but surer than a revolution, that one has arrived at the point to which experience has brought constructors in all countries, at least before the present exigencies of war, after they had allowed their imagination to wander in creating all sorts of unprecedented forms.

The four-engine Zeppelin in its turn is only an enlargement of the two-engine. One can almost say "This is a two-engine machine with four engines," for of the two-engine machine it conserves the essential dispositions, including that of the engines, in that they have been content to leave them in the same place, but placed end to end in the same position where the twin-engine machines have only had one. It is simply a question of the possibility of realising more powerful engines; the question of bulk, of dimensions and of resistance of materials, and not an affair of new conception.

It is the limit of the power of the German engines which seems to have forced on them the position of one airscrew in front and one at the back, and this disposition seems to be hardly more than an expedient, rather than a principle, of improving efficiency by the succession of the screws, which has imposed the splitting up of 1,200-h.p. between four separate engines.



Details of wing spar

VIEUX JEUX.

The same single fuselage, contrary to the Caproni and others; the same arrangement of wings, instead of triplanes with less chord; the same position of motors, etc., as in twin-engine machines; and even the undercarriage of these last, which is itself as nearly as possible the same as the single motors but doubled, and the same tail skid is found in the four-engine machines.

As to the controls themselves, they do not depart notably from the similarity, for we have in many biplanes ever since the beginning of aviation, even on fuselages as in the Dorand of 1913-1914, seen multiple rudders forming a closed cellule at the extremities, and the Germans themselves actually have in the Hannovrener a biplane tail in which the controls are disposed in a general way like those of the Zeppelin.

Also the German twin-engine machines resemble closely the single-engine and four-engine, so that one can say without pushing the paradox to the extreme that the four-engine machines descend directly from preceding German tractor biplanes of which, they conserve the general characteristics and aspect.

Over and above this, on the Zeppelin one perceives that the engineers have sought for simplification and have not adopted either a dihedral or an arrow shape to the wings, nor complicated curves, nor staggering, nor inclination of the struts, either in the cabane or in the fuselage, but have kept to horizontal and vertical lines, dimensions in round figures, simple and relatively uniform sections, few special attachments. To sum up, this is a machine of the brute force type, without the refined complications with which many German constructors are pleased.

REPORTERS' ERRORS.

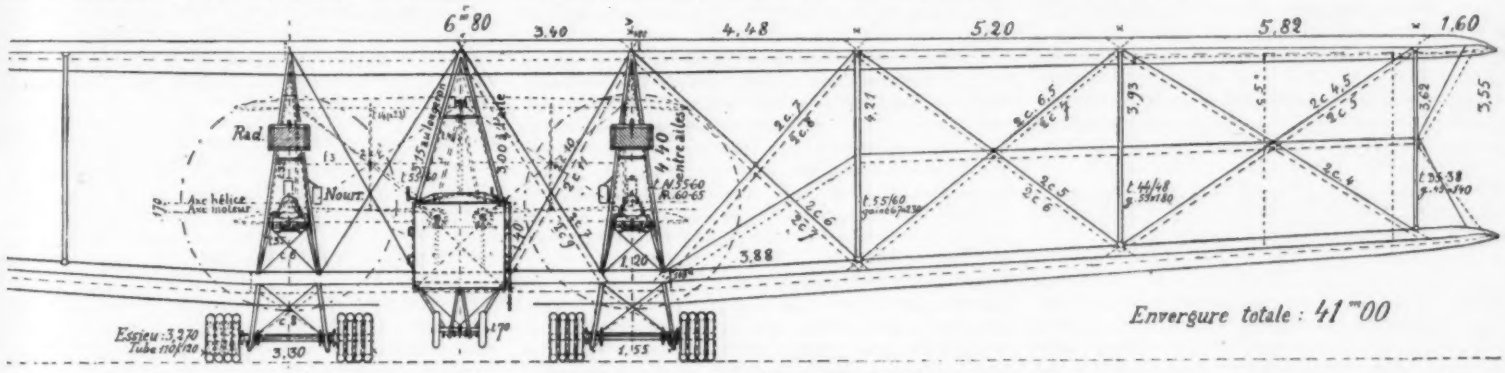
Before giving a detailed description of this avion, let us do justice to the errors committed in articles published on this subject. The published accounts give it according to their variances 1.4 ms. to 2 ms. span too much; 15 to 20 sq. ms. excess in surface; 1.5 ms. too little in length; others 6 ms. too much; 3 ms. too little in height, although the interval between the planes has been exaggerated in the middle and decreased at the extremities.

As to the weight published, it exceeded the truth by anything between 1,500 and 2,500 kilogrammes. In short, the giant is never so much a giant as in conveying that illusion, which is the more astonishing in that the accounts have decreased the h.p. by 200, and suppose it to be loaded at 14 kilogrammes per h.p.

Everything in the descriptions has been represented upsidedown. The arrow shape of the wings, which was attributed to the trailing edge; the centre section which presented a V and an arrow shape wrong way up, quite incomprehensible and unpractical; errors in the gap and chord of the wings; ailerons which were supposed to exist on both planes and obliquely; ribs which had to be oblique, because perpendicular to the leading edge; cabanes doubly unsymmetric in consequence of the erroneous V and arrow; the undercarriage quadruply reversed, the front behind and contrariwise; the struts in a vertical plane in place of logically prolonging the inclination of the A of the cabane; the outside struts unequal and too close together and entirely unlike the inside struts where they are in fact identical; the screws and the motor badly placed—too close together by 0.5 ms.; the fuselage which the screws would have cut to pieces because it was too large; the elevators 2.15 ms. apart instead of 1 m., and so forth. Apart from such things there was nothing left in the descriptions.

THE GIANT DESCRIBED.

In reality the total height is 6.4 ms. of which 1.5 ms. is under the fuselage and 4.4 m. between the wings in the centre section.



Front view of the four-engined Zeppelin biplane

The right wing is partly cut away so as to make the drawing as large as possible. M. Lagorgette has indicated in a most painstaking manner the sizes of tubes, cables and fairings. "t" stands for tube, "g" for "gaine" or fairing, "c" for corde or cable. "Nourr." on the side of the starboard engine stands for "nourrice," or nurse-tank." The word "longeron" written along the starboard leg of the fuselage cabane refers to the upper plane spar, and not to the fuselage longeron. The symmetrical arrangement of the engine-cabanes and their continuation to the under-carriage struts is noteworthy. The front elevation of the tail is shown in dotted lines behind the fuselage and engine-cabanes.

Total length, 22ms. Total span, 41 ms.

THE WING FORM.

Form.—The span of the lower wings is equal to that of the upper wings and the chord is the same except for a difference of some centimetres in the centre section. There is no stagger.

The upper wings have no dihedral, the lower wings only being so provided, and they also only have a dihedral outside the base of the cabanes which carry the engines, but what there is is accentuated. From 4.4 ms. at this point the gap decreases to 3.6 ms. at the tips, or 0.8 ms. decrease in a little less than 16 ms., or almost 5 centimetres per metre.

The two planes indubitably are arrow shaped only as to the leading edge, and in a somewhat marked manner. The whole recalls the form of the L.V.G. of 1913-17, and not that of the earliest Morane-Saulniers, of which the L.V.G. was the inverse.

From 4.5 ms. at the axis of the machine and as far as the summits and bases of the engine cabanes, the chord decreases to 3.5 ms. at the tips, or 1 m. of arrow in about 17 ms.—that is to say, about 6 cms. per metre. As to this arrow of the two planes, it is no less certain than as regards the V of the lower wings that it begins only at 110 mms. from the exterior bases of the cabanes and at 100 mm. from the summits. Beyond these points the gap of the wings is then at each point a little greater or a little less than their chord, and the average gap is equal to the average chord.

All these dimensions are, besides, confirmed by the height of the interplane struts as to the dihedral, and by the length of the compression tubes between the spars as to the arrow—that is to say, in plan and front elevation.

The trailing edge of the wings seen in plan is, as

distinct from the leading edge, a straight line. The wing tips are slightly oblique and rounded.

Surface.—The carrying surface of the wings is 314.5 sq. m., of which 14.5 sq. ms. is occupied by the two ailerons.

Incidence and Wing Section.—The incidence of the wings from the axis of the machine to the engine cabanes is determined by the two following points. The lower longerons of the fuselage being horizontal in front, the lower side of the front spar of the lower wing rests directly on their upper surface, while the upper side of the rear spar only comes flush with the upper surface of the fuselage longeron. This is to say, the angle of the under surface of the wings between the spars is fixed by the depth of the rear spar—that is to say, about 160 mms.

The incidence is thus approximately 0.45 mms. in the 4.5 ms. of the total chord, or about 1 in 10.

Even if with the idea of simplification, and, contrary to the rule of nearly all German biplanes, the angle of incidence does not diminish from the middle of the machine to its extremities, the difference in level between the leading edge and the trailing edge would decrease progressively in the same direction, since the wings narrow towards the tips, but as it seems certain that the curves of the wings are more accentuated towards the centre of the machine than at 15 ms. from the centre, where I have taken the curve illustrated in Fig 1, it is possible that the angle of incidence decreases correspondingly with the concavity of the wings.

As to the wing curve (Fig. 1), it recalls on a larger scale those which hitherto have been traditional on German biplanes, and much more nearly that of the wings of the Aviatik, C. type of 1916.

The leading edge is round—that is to say, almost a complete semi-circle.

Although the curve is more accentuated towards the centre of the machine than where the section has been taken, the curvature is relatively slight for such a machine, and, therefore, the incidence has to be quite considerable.

In spite of the enormous chord of the wing, 4.5 ms., there is no double curvature. The trailing section of the wing is flat below and very slightly convex above for 1.5 m.

The maximum thickness, 0.22 m., is by no means extraordinary, because, on the new small Fokker chaser biplane, it is 0.24 m. on the upper wings.

WING STRUCTURE.

Wing Spars.—There are two principal spars which are true girders, a third spar, the shape of a gutter placed on its side, holds the ribs .75 ms. from their ends. In the upper planes this only runs as far as the beginning of the ailerons. The aileron spar, also of a gutter section, supports the aileron hinge and is placed about a metre from the trailing edge.

Both of the true wing spars cross the fuselage at their different levels. The front spar on top of the lower fuselage longeron to which it is held by eight bolts. The rear spar comes flush with the longerons to each of which it is united by a heavy spar-box of a T shape, which spar-box also serves for the fixing of the rigging cables.

By this continuity across the fuselage it is possible to dispense with special compression tubes, and the position of the leading spar of the wing permits the existence below it of the metal cross-bracing of the fuselage (Sketch E. in general arrangement drawing), while the rear spar itself fulfils the purpose of a similar cross member.

Each of the spars is composed in the course of its length of three pieces, each a straight line. The rear spars are assembled all three in a straight line, but the front spars, outside the engine cabanes, are set back in the arrow shape, and as regards the lower wings, both spars are assembled to give a dihedral.

Thus the centre part of the spars which traverse the fuselage are a single piece in a straight line without either arrow or dihedral as far as the outside of the engine cabanes.

This division into three parts does not cut the spar up too much and proportions the length very well, contrary to what would have happened if the spars had been arrowed right up to the axis of the machine.

Moreover, the straight disposition of the central parts of the wings, which is so simple and natural, and has already been applied to all the twin engine German machines without exception, is evidently necessary to give the under carriage and the engine cabanes a foundation which is neither oblique nor inclined in either direction, without counting the facility of attachment and rigidity of connection of the fuselage.

The two assemblages of the three portions of each spar are arranged in the following way: The two extremities of the neighboring portions terminate in a rectangular section and are brought together in a powerful collar by strong bolts lying in the direction of the span. They can, therefore, be dismounted in case of need, but this dismounting would be slow and an exceptional business. Moreover, in this machine, except for the tail and the undercarriage, there are no facilities for dissembly as is common in other types of German machines.

The height of the spars are as follows: Front upper spar 148 to 149 mm., front lower spar 140 to 144 mm., rear upper spar 162 to 167 mm., rear lower spar 161 to 155 mm.

These dimensions are maintained to within .6 or .7 ms. of the wing tip. But by a particular and even singular disposition, and one which is worthy of attention, on each side of the interplane struts the width of the spars, and not their height, has been thinned down for almost a third of their length.

This width which is normally as follows: 78 mms. to the upper front spar; 91 mms. to upper rear spar; 62 to the lower front spar and 89 mms. to the lower rear spar, changes quickly from 78 mms. to 72 mms., from 91 mms. to 85 mms., from 62 mms. to 56 mms. and from 89 mms. ot 83 mms., for 1.7 ms. of the span in a length of 5.2 ms.

Then, by an equally abrupt reversal, they return to the original dimensions which they maintain for 1.9 ms. of their length in 5.8 ms., returning afterwards to the reduced section for 2 ms. of the length, and afterwards going back to the greater dimension at 1.9 ms. from the external interplane struts.

Towards the extremity, besides this reduction, the section of the spars diminishes progressively for 0.6 to 0.7 ms. in the following manner: For the upper front spar down to 75 × 75 mms., for the upper rear spar 83 wide × 63 mm. high, for the lower front spar 75 wide × 55 mm. high, for the lower front spar 83 wide × 60 mm. high.

These figures show that the front spars are reduced in both directions, and the rear spars in thickness only. But one must observe that, besides, the front spars are thinned down on their upper side as well as lower side, while the rear spars are only thinned on the lower face, in such a way as to provide a more accented raising of the wing surface towards the extreme rear angle of the lower wings, as well as the upper, in the latter of which this lifting (or washout) is prolonged dy the aileron.

As may be seen in Fig 1, each spar forms a double box composed of seven grooved pieces assembled, glued and reinforced on the two sides by one or two layers of ply-wood, then wrapped with fabric in a spiral before placing the ribs in position. At the points of attachment and at the centre they are left solid. The upper spars, as well as being larger, especially the rear spar, are made of ash, and the lower ones of spruce.

The little supplementary spars are of spruce. The leading edge is a semi-circle of spruce.

Ribs.—Outside the central fixed part where they are perpendicular to both edges the ribs form with the leading edge and with the front spar an angle clearly obtuse on the side of the fuselage and acute on the opposite side, while they are perpendicular to the rear spar and trailing edge. The same is true of the compression tubes situated between the bases of the interplane struts.

All measurements confirm the fact that the ribs and the bases of the interplane struts are parallel to the axis of the machine and that the arrow of the wings only exists on the leading edge. The construction of the ribs recalls that of the Handley Page, also of certain Albatroses, and specially that of the framework of the Zeppelin airships.

There are top and bottom flanges glued and nailed to a central web, also in spruce, which is bedded into the flange. Webs in the form of double laths unite the opposite flanges, and in the case of those in compression are made into boxes by the addition of three-ply strips. They are disposed in zig-zags and fixed to the web of the rib by duralumin rivets.

All these wooden elements are glued. The ribs are nailed to the spars. Everything except the ply-wood is made of spruce. The trailing tip of the rib is sheathed in a sort of square thimble of thin brass. The trailing edge of the wing is held by a simple piano wire which goes through this thimble.

The distance between the ribs, which is enormous, varies from .565 m. to .43 m. It is less in the vicinity of the airscrews.

Between two neighboring ribs a flat lath, 15 by 10 mm., extends to the leading edge above the front spar to maintain the shape of the fabric.

On top of each rib the fabric carries a strip of braid glued outside. It is fixed to the ribs by a thread which passes over this tape and on top of the lot is glued a strip of fabric 3 to 4 cm. in width.

Between the spars two series of bands pass alternatively over and under the ribs of the flanges to which they are nailed, maintaining the position of the ribs laterally. Exactly in the middle between the interplane struts two ordinary ribs are much closer together than the others, being .15 m. apart. They maintain the distance between the longerons against the compression which is exercised by the secondary cross-bracing in the vicinity of these ribs.

Bracing.—The wings have a double system of cross-bracing, one between the bases of the struts, which is very long and consists of thick cables, and the other is in simple 3 mm. piano wire joined to the ends of the twin ribs which are placed half-way between the struts.

These wires, by a curious disposition in crossing the spars, penetrate through them obliquely, and they are connected to a simple nut and bolt arrangement. In the spruce block situated in the exterior angle between the rib and spar they are fixed solely by the pull of the turnbuckle.

The long cable bracing is fixed to the extremities of the compression tubes. This extremity is fixed to the spar by two lateral lugs, pierced with holes, to which are attached the cables and wires of the cross-bracing.

Compression Tubes.—These are situated between the extremities of the interplane struts, and between the engine cabanes. They serve at the same time to maintain the distance against the incidence bracing. Given that there are two for the base of each cabane, and a single one for the single summit, there are altogether ten in the lower plane, and eight in the upper plane, a number which is frequently surpassed in the small German aeroplanes.

The tubes are round, 50 mms. in diameter, for those at the summit of the cabane, 45 mms. at the base of the cabane and decreasing, as they get away from the centre of the machine, from 40 mms. down to 12 mms. between the external masts.

INTERPLANE BRACING.

The whole of the strut and bracing arrangement is clearly initiated from the "Bréguet de bombardement" of 1914-16. Besides the central cabane on the fuselage there is on each side a cabane for the engines and three pairs of interplane struts.

Cabanes.—Each of the three cabanes, quite simple and brutal in design, is composed of two A's, of which the bases and summits are fixed by sheaths to the wing spars, or to the fuselage in the case of the base of the central cabane, and they are interconnected by compression tubes inside the wing and bolted to the sheath.

The width of the engine cabane at the base is 1.2 ms., both front and rear, and the distance between the A's longitudinally is 2.48 ms. Each of the A's is of round tube, 55 × 60 ms., except the rear tubes of the engine cabanes, of which internal and external diameter are 60 × 65 mms. The cross-piece is of 32 mm. tube.

Interplane Struts.—These are parallel to one another and vertical; of round steel tube with conical ends stuck inside and welded. They are bolted into lugs on the bottoms of which they press, which lugs are themselves raised on a large steel sheath surrounding the longeron without being imbedded in it.

Their diameter and thickness diminish from the internal pair (55 × 60 mm.) to the intermediate pair (44 × 48), and the external pair (35 × 38 mm.). These dimensions in each pair are the same for the front and rear struts, contrary to what would have seemed natural and to what exists in the legs of the engine cabanes, and for the front and rear cable bracing.

They are surrounded by fairings of 3-ply with little interior ribs, as on the Bréguet, open at the top and bottom to enclose all attachments. The dimensions of these fairings vary proportionately to those of the struts.

Bracing.—The cables are disposed in transverse and longitudinal X's. As regards the longitudinal cables, there are two cables from the top of the front strut to the bottom of the rear strut, and one from the top of the rear strut to the bottom of the front srtut.

By a disposition peculiar to this machine, and general in the bracing in other directions (except transverse) of its fuselage, each transverse cable of the wings as well as in the stabilising planes is formed of an endless cable. Or, more exactly, after it has been passed diagonally round three faces of the wing spar, without having been linked to a fixed point, but passing simply in a groove or gutter welded on to the

sheath of the spar, one of the extremities of the cable returns from the opposite side towards the other extremity with which it is linked by the turnbuckle. It is thus, in a sort of way, doubled, but although weighing double, it does not offer double strength or double security. (There are 450 ms. of transverse cables between the wings, of which 400 m. operate in the fashion described, and there are about 2 kilometres of cable and wire of various sorts, weighing some hundreds of kilogrammes in the whole machine.)

Undoubtedly this procedure ensures a certain elasticity from which the avion and the cable itself profits, but if a rupture occurs the entire cable ceases to fulfil its functions, because, having one point of attachment, instead of having four, it slacks off and offers no resistance to strain. One can only see in it inconvenience in compensation for very slight and problematic advantages.

An analogous system was applied on the Zeppelin airships in which it was impossible to have absolute rigidity, and if the engineers of this firm have adapted it to avions in the same way as the employment of aluminium, it is undoubtedly because of the psychological influence of tradition not less than for the doubtful technical reason of suppleness.

The ferrules on which these gutters are welded are single for both neighboring cables.

Instead of being separated by the thickness of the spar for the rest of their distance between the wings, the two parts of the same cable are pulled together by ligatures at a distance of about 4 ms. from their exit from the wing, and up to that point the triangular loop which they form is enclosed in a fairing of hinged aluminium which can be opened.

To avoid distortion of the struts an almost horizontal tube links at mid-height each front strut with the strut behind in the same pair.

Moreover a set of cables of which one extremity is fixed at the intersection of the wing spars with the bases of the engine cabanes runs transversely at half their height from the internal struts to the external struts, and thence terminates .08 or .1 ms. from the extremity of the spars, thus linking up by cable the ends of the horizontal steel tubes already mentioned.

At the crossing of these cables with the transverse bracing cables, the cables are enclosed in a little fairing of poplar profiled in the form of a hollow olive. This fitting is also copied from the Brégnet. Over and above this, all the cables, including the double transverse cables, are enveloped in a fairing of light ply-wood surrounded by glued fabric.

There is nothing remarkable about the turnbuckles except their proportions.

Ailerons.—As in all German biplanes, except the Albatros, C. type, and the Friedrichshafen, ailerons are only fitted to the upper wings. In spite of the gutter shape form of the third spar it is fairly certain that this would not serve as a hinge fixing; and that no ailerons exist for the lower wings.

The ailerons are rectangular and do not project. The outer angle is rounded, as are the tips of the lower wings, and is slightly raised towards the rear tip, according to the German habit. They are not balanced, contrary to another habit, and this characteristic seems singular when one recalls the effort necessary to manœuvre the machine even if there were two pilots. And what is more strange the elevators are not balanced either, although there is no servomotor.

The maximum span of the ailerons is 7.16 ms. and chord 1.02 m., measured from the middle of the 60 mms. tube, which acts as a hinge, and which is imbedded up to that point in the gutter-shaped false spar which supports the ailerons.

Their surface is thus 7.25 sq. ms. each, and their total surface 14.25 sq. ms., which is more than the total surface of certain Morane monoplanes.

Their structure is entirely metallic, being made of steel tubes like those of the ailerons and rudders of all German aeroplanes, though the rudders of the Zeppelin itself are of aluminium. The idea in this is doubtless to give enough strength with slight thickness, and to avoid the warping of the wood.

As on the larger number of German biplanes the ailerons are controlled by means of two sheet-steel levers, 4. ms. long in the arm. These levers are lodged in the thickness of the wing in front of the pivot, and are attached by other cables to the lower plane.

The ribs, spaced .5 ms. apart, corresponding to those of the wing, are composed of two steel tubes in an elongated V surrounded at half their length by a little band of sheet steel welded to them which maintains their distance. The two rear extremities, to decrease the thickness, are welded one alongside the other, and not one on top of the other, to the trailing edge of the aileron, which is also of steel tube, 25 by 14 mms. Other tubes of 15 mms. are disposed crosswise as bracing. All these tubes are wrapt with light fabric, on which is struck that of the ailerons.

THE TAIL.

Controls.—The tail of the Zeppelin is the least banal part of the machine, on account of its structure, no less than on account of its dimensions. It is remarkable for the turning of its curvature upside-down, and for the large and almost exclusive use of aluminium. Enormous and heavy, each of its planes would have a surface sufficient to build a monoplane, and, as a whole, they would form a small two-seater biplane, or a large single-seater.

Tail Planes.—The tail planes, or longitudinal stabilisers, partly fixed and partly mobile, are biplanes. Not only are they of a surface equal to that of a biplane, but they are a complete biplane in general structure, internal constitution, cabane, struts, bracing, etc. This cellular character permits one to fix the tail at suitable horizontal points on the fuselage, which is flattened and raised and built as high as possible to avoid accidents on landing. The directional controls, or rudders, are included between the altitude controls.

The tail planes are of a rounded arrow shape very much accentuated, and their aspect in plan is exactly that of a Taube. The analogy is striking and complete and cannot remain unnoticed. Thus often in order to innovate something the Germans return to their ancient conceptions.

The tail planes are not staggered.

In spite of the difference in the centre, due to the fact that the lower tail planes are fixed on the sides of the fuselage, they are equal in span (9 ms.) and in chord.

The gap is 2.15 ms. much greater than that of an ordinary biplane, and greater than the chord.

Fixed Portions.—The incidence of the upper surface which is adjustable is sufficiently great (.17 ms.) in a chord of 1.57 ms., or about 1 in 10, which is about the same as that of the wings. That of the lower face is still more marked.

This is made necessary by the weight of the tail, but comparison with ordinary planes would necessitate a special examination, for one characteristic which is peculiar and worthy of remark is that the curve of the tail planes, which is very much like that of current types, is completely reversed. That is to say, the upper face is absolutely flat, while the lower surface has a curve similar to that of the upper surface of the wings. That is to say, it is convex instead of concave to the extent of having 112 ms. thickness.

The section of the elevator flap proper is triangular with a slight curve on both faces.

As regards this singular disposition, is it likely to improve climb? It can hardly do so, and anyhow its climbing must be painful enough, considering that the elevator by an astonishing departure from the rule of most German aeroplanes is not balanced in any way.

Structure.—Each of the two fixed stabilising planes is composed of two parts. The cabane which links them up is composed of two inverted V's with tubular cross-bracing between the summits, and reposes at the rear on the terminal transverse member of the fuselage. At the front it rests on a single transverse piece linked at its extremities to two mountings in slotted steel tubes on which it is adjustable by two ferrules held between two screws. Thus the incidence of the upper plane is fixed in relation to that of the lower plane.

A slight interval separates from the fuselage the two parts of the lower tail plane.

The ribs are of spruce and of the same type as those of the wings. The width of the ribs is 15 mms.

The struts are of 40 mm. tube, and are made of duralumin.

Two cables link the fuselage near the fifth cross partition to the summit of the rear struts of the tail, and two others link it near the fourth division to the front summit of a cabane Two pairs of cables hold the cabane longitudinally, besides a pair in the central fin.

Mobile Portions.—To the rear spar is linked by eight hinges the elevator flap, which is a single flap for each plane, although its pivot is composed of two pieces placed end to end on the axis of the machine and bolted together.

The ribs of the moving part are similar in type to those of the wings and the fixed part, but are of duralumin in a U-shape, slightly closed in to avoid tearing, or wear, by the cross pieces.

Rudders.—The rudders, which are three in number, are connected to fixed fins, one of them fixed on the axis of the machine, and the others 3.5 ms. out on each side. They are all entirely comprised inside the level of the two-tail planes, even to the extent of leaving a slight margin of 8 to 10 cms.

The rudders have a similar form, but the central fixed fin differs from the other two. Mounted on a veritcal duralumin tube between the front struts of the cabane, this central fin is prolonged as far as the fifth transverse member of the fuselage in the middle of which it is fixed at its leading point, while the two other fins mounted on the front struts of the tail are only prolonged forward a little way. At the trailing edge all three of the fins are limited partly by the longitudinal bracing to which they are fixed by their duralumin edges. The rudders are mounted on the rear struts or on the vertical tube (which is a shade shorter)—also of duralumin—which is situated between the rear struts of the cabane. In front of these pivots is a balanced portion which extends to the vicinity of the cross-bracing to which the fixed fins also extend from the other direction.

The fixed fins and the rudders are entirely constructed of aluminium. Their ribs consist of little aluminium girders, analogous to those of the elevators and very similar to the girder work of the Zeppelin airships.

For the rudders the control cables, after passing over horizontal pulleys near the fifth transverse member of the fuselage, set out obliquely, and one cable passes through a window in each of the external fixed fins to a single transverse lever on the outer rudder. It seems then the more necessary that the three rudders should be linked up so as to be movable in both directions.

Surfaces.—The fixed tail planes have a surface of 20 sq. ms. The elevators have a surface of 5 sq. ms. The outer fixed fins have each a surface of about 2 sq. ms. and the central fin measures at last 1.5 sq. ms., more by reason of its leading triangular part, so that the total surface is about 7.5 sq. ms. for all three.

The three rudders have a total surface of at least 4.2 sq. ms. Of this for each there is 1 sq. m. in the trailing portion and .4 sq. m. for the balanced portion. That is to say, a balance of about a third.

[TO BE CONTINUED.]

Light Emission of Gases and Gas Mixtures by Electric Discharges

THIS paper gives a short account of the most important results obtained in an investigation on the influence of different factors upon the emission of light by gases and gas mixtures due to electric discharges. The method used was that of Holst and Hamburger. The discharge apparatus was similar in construction to the continuous discharge apparatus of Konen and Jungjohann, in which streaming gases were used. Investigations were made on N, Ar, Ne, and He. With N it was found that the emissve power is proportional to the supplied energy. For constant current-density the intensity of the light decreases with a decrease of the pressure over the range investigated, and at the same time the maximum of the emitted energy is shifted towards the shorter wavelengths.

At a change of the pressure of the gas the bands belonging to the negative pole show a characteristic difference in behavior from the bands of the second positive nitrogen group which surround them. The potential gradient in the positive column decreases with decrease of pressure and also with increase of the current intensity. Near the kathode the passage of a current gives rise to a decrease in pressure, which for high values of the current density is relatively great, and the value of this pressure effect is approximately proportional to the current intensity. There is a corresponding pressure-increase at the anode. The pressure effect is found to be smaller in gases with lower molecular weight. Observations on H, Ne, and He are in general agreement with those on N. In all cases the intensity of the spectral lines or bands is proportional to the supplied energy, and with decrease of pressure the energy maximum is shifted towards the ultra-violet. With Ar the red and blue spectra exhibit totally different behavior with respect to the supplied energy. With increasing current strength the intensity of the red Ar spectrum at first rises rapidly and afterwards more slowly. With the blue Ar spectrum the reverse is the case. In the case of mixtures which do not react it was always found that a decrease in pressure causes a shift of the max. light emission towards the ultra-violet. With the reacting mixtures N–O, N–H, and N–CO, in each case the reaction was accompanied by the occurrence of new bands. Investigation of the system N_2–H_2 supported the view that electric ammonia-synthesis is preceded by a disintegration of the reacting molecules into atoms.—*Note in Sci. Abstr. on a paper by L. Hamburger in U. Akad. Amsterdam.*

Respiratory Diseases in the Army

The incidence of communicable diseases in the United States Army during the preceding winter gave rise to various criticisms, some of which were undoubtedly justified by reason of the rapid mobilization of the National Army. The hurried transformation to soldiers of untrained men from all parts of the country most naturally was accompanied by a marked increase in morbidity and mortality such as would have occurred, even if the purpose of the assemblage of such large groups had not been military.

An investigation into the causes of the frequency of communicable diseases in the National Guard and National Army during the six months from September 29, 1917, to March 29, 1918, by Colonel Victor C. Vaughn and Captain George T. Palmer shows that, all things considered, the death rate in the army was not as great as many estimated it to be. Exact figures are not available in view of the fact that the draft age, for example, was 21 to 31 years, while the mortality statistics by decades have been based upon a group 20 to 29 years of age. The army includes more above than below the draft age, and for this reason the death rate in the army would normally be higher than that of the 20 to 29 year group in civil life.

It is striking, also, that the annual death rate per thousand varied exceedingly in different sections of the country during the period under consideration, to illustrate: Camp Wheeler had an annual death rate per thousand of 28.3; Camp Bowie, 23.1; Camp Shelby, 8.6; Camp Wadsworth, 2.5; Camp Logan, 2.3. These camps of the National Guard, containing for the most part men with some degrees of training had, as a whole, slightly lower rates than the camps of the National Army. Camp Pike had a rate of 30.7; Camp Funston, 16.3; Camp Upton, 5.3; Camp Dix, 2.9. The only facts evident are that camp life may be made reasonably safe, in fact as safe as some of our best protected municipalities.

The wide variations in death rates were found to be due to a variety of causes none of which was of more importance than the fact that the highest mortalities and morbidity were found in those camps which have acted as filters, through which numerous troops have passed, leaving the most unfit behind. Data thus far available do not reveal very many important effects of race, nationality, or section of the country from which troops have originated, except that under similar conditions the negro has again shown himself to be more susceptible to acute respiratory diseases than the northern white man.

It must be a source of satisfaction to the medical community to learn that, "There is no reason for believing that either morbidity or mortality in any camp has been due to faulty sanitation, as we usually understand this term. All the camps are kept clean, have unquestioned water supplies, satisfactory garbage and sewage removal, etc." This is quite in harmony with the fact that the annual rate for the three organizations during the period studied was, National Army, 9.6; National Guard, 9.5; Regular Army, 7.8.

In civilian life, for the age group under consideration for the period of time studied, respiratory diseases, including pneumonia, meningitis, measles, scarlet fever, diptheria and tuberculosis were responsible for 43 per cent. of the total mortality, while for all the troops in the United States the same group of respiratory diseases caused 77 per cent. of the mortality.

It is patent that the main attack upon the mortality rate of the army in camps requires attention to the respiratory diseases. Vaughn and Palmer call attention to the fact that about 80 per cent. of the deaths from the respiratory group are attributed to pneumonia, meningitis being responsible for 15 per cent., with five per cent. to be accounted for by tuberculosis, measles, scarlet fever, and diptheria.

The prevalence of disease according to the authors may be attributed to one or more of the following causes:

"1. Weakening of the resistance of the soldier due to
   (a) Exposure to severe weather.
   (b) Insufficient clothing.
   (c) Inadequate housing, lack of heat.
   (d) Fatigue.
2. Unusual facilities for the transmission of the infective agent by
   (a) Close contact with carrier cases.
   (b) Undetected cases among new recruits.
   (c) Importation of mildly sick men and carriers from other camps.
   (d) Association with civilian communities.
   (e) Overcrowded quarters.
   (f) Inadequate hospital care of patients.
   (g) Insanitary conditions in general.
3. Natural susceptibility to disease.
   (a) Racial influence.
   (b) Effect of rural life.
   (c) Climatic influence."

A careful study of these above mentioned factors in a most impartial manner leads to the conclusion "that the greatest single factor in the prevalence of disease in certain camps and their absence in others has been the natural susceptibility of the men." Inherent susceptibility to respiratory diseases, physical inferiority, due to debilitating diseases such as hookworm, malaria, pellagra, inadequate dietary, and promiscuous spitting are more fundamental than the aggravating factors incidental to army life. Exposure, fatigue, the lack of warm clothing, insufficient bedding, cold quarters, naturally further decrease their resistance. The mere presence of a disease carrier is sufficient to start an epidemic.

The most significant suggestion made for preventing a recurrence of respiratory diseases during the coming winter is contained in the following paragraphs:

"First and foremost it seems necessary to graduate the introduction of civilians into army life. The change has been too abrupt. Men should be called first to a semiactive reserve army. Here they should get drill and the essentials of sanitation and self-care by lecture and by demonstration. The drill and calisthenics should be the hardening process. After this the transfer should be made to camp where a man's entire time is given over to his military training."

"Before entering camp men should be examined for incipient diseases. The suspects should be separated and watched before their despatch to camp. Vaccination for typhoid and smallpox can be completed while in the reserve force.

"Once established in camp the transfer of men from one camp to another should not take place without a careful examination and removal of those who show signs of illness. This will prevent this all too frequent transportation of sick men, who are dangerous to others because of their sickness."

"These precautions together with care in the proper mixture of work and rest, judicial selection in the quality and balancing of the food ration, the adequate protection of the man, especially the one from the warm climate, against cold and exposure, his protection against the sick through effective quarantine measures, and discretion in the use of the physical hardening process should moderate to a large degree the experiences of the past winter."—*American Medicine.*

Synthetic Gasoline by Electrochemical Means

UNDER this ill-chosen title, Mr. L. Bond Cherry described last October some experiments on what might be characterized as a High-Tension Discharge Cracking Process; the experiments have been conducted on a fairly big scale. He passes mixtures of petroleum vapors and hydrogen (or natural gas, etc.), through electrically-heated iron tubes while high-tension, high-frequency currents are sent through the axial wire electrode of each tube. The process is thus a combination of the ordinary cracking process and the Cottrell process; but the inventor claims that the high-frequency discharge does away with the need of high pressures and prevents the deposition of carbon at high temperatures and the formation of olefines. A further novelty is that he introduces the gas (natural gas, steam), the hydrogen of which is to combine with the hydrocarbons through a perforated pipe under pressure into the oil in the still, thus facilitating the evaporation of the oil. He first experimented with tubes (iron pipes), 3 feet high; the height was afterward raised to 10 feet, and even to 34 feet, and finally a conversion of 84 per cent of the heavy oil into a gasoline was obtained; Cherry did not give any analytical data, but merely gravity figures, however. The actual equipment (locality not mentioned), is for heating 60,000 gallons of oil per day by currents of more than 35,000 vibrations per second at tensions ranging from 25,000 volts up to 250,000 volts. The construction of the plant for work at high temperatures, (up to 538 deg. C.) and pressures (5.5 atmospheres) naturally caused serious difficulties, and working at atmospheric pressure was for this reason adopted. The paper says more about parts of the apparatus than about the actual working, and the whole would be more impressive if statements like the following had not been made: "After studying the electromagnetic theory of matter it was conceived that, if the only difference that existed between carbon and hydrogen and between the lower and high members of the paraffin series was the number and organization of infinitesimal units of electro-radiant energy which we are pleased to term electrons, and if we mechanically mixed vapors . . . and impressed upon the mixture electro-radiant energy of the proper periodicity . . . " However, it seems evident also from the description of the paper, that the problem has been attacked in a practical way, and it might certainly be an advantage if some such treatment could be combined, as is suggested, with the crude-oil distillation in the refineries. Electric heating of the tube is considered necessary because a careful temperature control is required. It is certainly remarked that the high-tension discharge should prevent the deposition of coal on the hot iron walls.—*Engineering.*

Probable Number of Nebulæ

ESTIMATES of the probable number of nebulæ based on photographs taken with the 60-in. reflector at Mt. Wilson and the 36-in. Crossley reflector at Mt. Hamilton differ considerably. The author has made a new calculation, taking account of zonal distribution from the plate center, to allow for field distortion. His amended estimate of 262,000 possible nebulæ is still so much less than the 500,000 suggested by Perrine that Fath suggests the discrepancy may be due to lack of uniformity in the distribution of the Crossley plates.—*Note in Sci. Abstr. in an article by E. A. Fath, in Astron. J.*

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Table of Contents

	PAGE
The Determination of Stellar Distances.—By Sir F. W. Dyson	306
Four-Cycle vs. Two-Cycle Diesel Engines	307
Backing Photographic Plates	307
Are You Collecting Sphagnum?—By Prof. George E. Nichols.—2 illustrations	308
When the Dog Goes to War	311
Cork Slabs from Cork Waste	311
Mechanical Cavalry.—9 illustrations	312
Die-Casting of Aluminium Bronze.—By H. Rix and H. Whitaker	314
A Nursery of Broken Ships	315
Uvachromie	315
The Zeppelin Biplane—I.—By Jean Lagorgette.—3 illustrations	316
Light Emission of Gases and Gas Mixtures by Electric Discharge	319
Respiratory Diseases in the Army	320
Synthetic Gasoline by Electrochemical Means	320
Probable Number of Nebulae	320